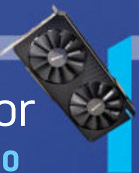

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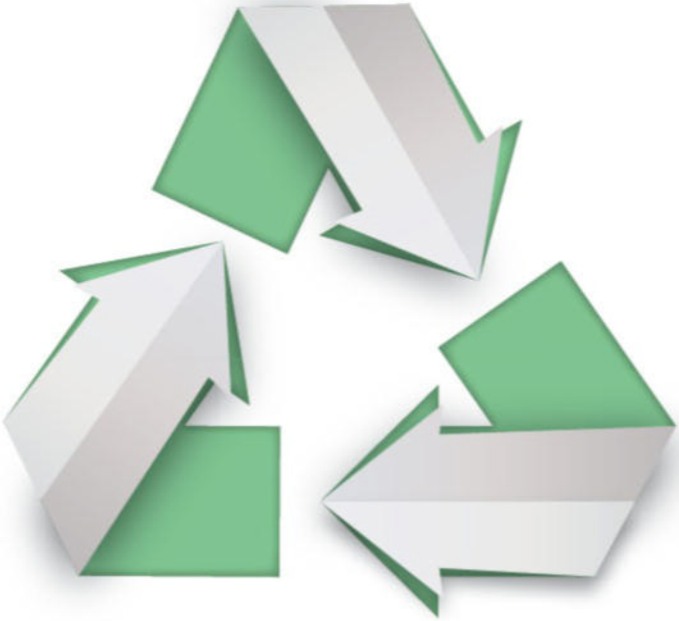

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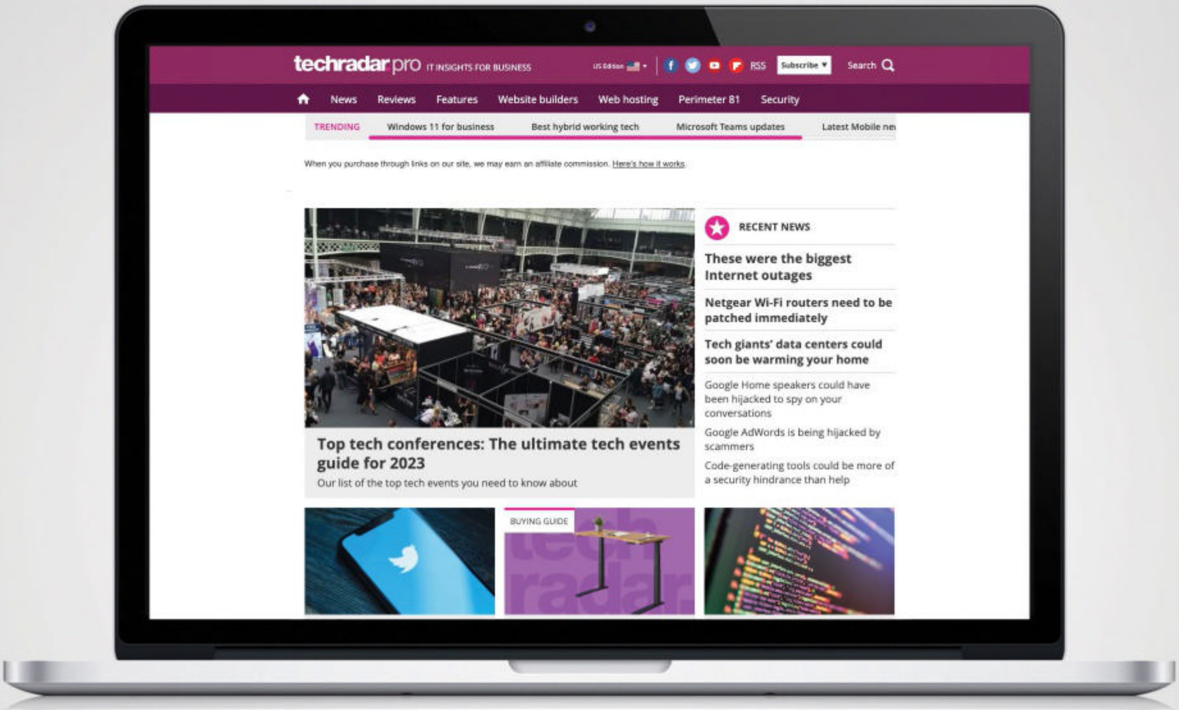
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Guy
Cocker

DIGITAL NATIVES

AS YOU MAY HAVE GUESSED by the fact that you're not holding a physical copy of Maximum PC this month, we're becoming a digital-only publication from this issue forward. Sadly, the rising costs of printing and distributing the physical edition of Maximum PC were no longer viable, and while I know that will be a disappointment to many of you, we made the decision to pivot to digital now so that we're able to continue to bring you the title you love. And that's exactly what we're doing: the same magazine, the same number of pages, and the same features as before, just in a new digital format that you can access anywhere you have a device.

We're also taking this opportunity to add more content to the magazine in its digital format, such as this issue, where Sam and I discuss the story of this issue's cover build in audio form (see page 16). A lot of you have told me you love hearing about the challenges we face when building PCs and how we overcome them, problems which are sometimes only briefly explored in text form. In audio, we're able to go into much more detail, from how we come up with the ideas for our builds to an insight into what we're working on next. As always, I'd love to hear from you about what you'd like to see from us, so that we can deliver you even more of Maximum PC in its new digital format.

To our loyal subscribers, this move has also allowed us to address one of your most-requested features, which is to create a digital archive of easily accessible back issues. We now have over 140 issues available going back over the last 12+ years, so you can check out historic reviews, re-read your favorite features, or just enjoy a spot of nostalgia to see how far we've come over the last decade. The move to digital also allows us to keep the magazine more current and relevant than before, as we can work closer to the on-sale deadline, meaning our news and reviews will be fresher than ever.

Whatever you think of our move, please tell me on editor@maximumpc.com. I read every email and will include the best correspondence in a future Comments section (see page 94).

As for what we've been working on this issue, we lead with a new budget gaming build that Sam put together using the latest components. Incredibly, that includes an Intel 13th generation processor, discrete Arc video card, and 1TB of SSD storage, yet clocks in at quite a bit less than $1,000. Sam also made sure his Corsair case had plenty of space for upgrades, meaning it should be usable for many years to come. Turn to page 16 to find out more.

We also lead this month's reviews section with AMD's Ryzen 7950X3D—the company's fastest-ever gaming processor. Is the addition of of a 3D cache enough to get Zen 4 ahead of arch-rival Intel and its newly-released unlocked Core i9-13900KS? Turn to page 74 to find out.

Elsewhere this issue, Jeremy Laird has a fascinating look at how PC screen tech is shaping up this year—it's LCD vs miniLED vs OLED on page 32. Plus, on page 56, we explain how CPUs work, take a look back at some of the most influential chips ever, and see which company is the one to watch as we push Moore's Law ever harder.

Enjoy the issue!

Guy Cocker

Guy is Maximum PC's Editor-in-Chief. He built his first gaming PC in 1997 to play Tomb Raider *on 3dfx, and has been obsessed with all things PC ever since.*

↘ submit your questions to: editor@maximumpc.com

THE NEWS

AI to rule the world

Experts call for pause before we do something we regret

AFTER QUIETLY working in the background of many applications and services for years, AI has hit the headlines. ChatGPT has become the fastest-growing consumer application ever, surpassing 100 million users, doing in four months what took Twitter five years.

ChatGPT is just the vanguard of a major shift in how computers are going to be used: an explosion of AI, and not everybody is waving flags of support. An open letter has been published, signed by some of the world's most influential technology experts, asking for a pause and some reflection. It warns that AI could prove hugely disruptive, alter the future of life on Earth, and that the rapid development means even AI creators can't control, predict, or even fully understand what their systems are doing. It calls for a period of planning, and careful management commensurate with the power AI has, which isn't being done. Alarmist? Well, among the 1,124 signatures are Steve Wozniak, Elon Musk, and many of the world's most revered AI researchers and developers. Elsewhere, Jaron Lanier (who is always worth a listen) says the more sophisticated technology becomes, the more damage we can do with it, and that we have a moral responsibility to use it humanely. The changes will go way beyond a chatbot or some generated artwork—AI is going to change the world.

From obscurity to fame in months: ChatGPT has awoken the world to the tide of AI.

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AI, and the machine learning that underlies much of it, isn't your traditional program. Inputting data doesn't produce a predictable result—you actually don't even know how the result is reached, as the working is hidden. ChatGPT highlights many issues with AI that few currently appreciate. It suffers from what are termed hallucinations, basically misinformation presented as true. It can amplify false narratives, entrench prejudice, enhance underlying bias, promote the reprehensible, and simply become stuck on a single answer to a question with no single answer. Still want it to control something important?

Microsoft has added GPT-4 (ChatGPT's AI engine) to Bing, while Google has its Bard system, which it says isn't a search engine, but a "fun toy". The results can be good, and entertaining if you ask the right questions. However, these are not your traditional web crawler searches with bells and whistles on; they create an artificially constructed reality as an answer. Early tests have shown some alarming problems, from getting simple verifiable facts wrong, to more sinister issues. One journalist enquired about themselves, and were told of their death. ChatGPT provided a link to a non-existent news article that would prove it.

It's early days, and there are rough edges. The first models would hand out information of all sorts of despicable acts, complete with instructions that required much human intervention to fix. It remains to be seen if these new AI-powered 'searches' are useful, but for now we have an experiment being conducted on a large scale by people who don't understand the parameters. Pundits have warned that AI will disrupt Google's main bread-winner: selling adverts linked to searches. Oddly, Microsoft has lost its entire AI ethical team in a round of job cuts, which can only be seen as poor timing.

Jobs are on the line: academics estimate that about 15 percent of all tasks could be automated—including this one. Creating content is one of the more vulnerable. It has been predicted that generative AI will dominate the internet within years. This raises the prospect of AI models feeding off their own output, which can't be a good thing.

AI isn't exactly new, with the first program exhibited at a conference in 1956. What has held it back was the scale needed to get it to work effectively. We have that now: rack upon rack in server farms coupled with vast reservoirs of data culled from the internet and smart phones. AI is smart, but it isn't *that* smart. After years of research, we're still struggling to get AI to drive a car, even under ideal circumstances in a controlled environment, as San Francisco is finding out.

The AI genie is out of the bottle. We now need to learn to live with it, and appreciate what it can do, and as importantly, what it can't. Warnings of a dystopian future may be unfounded, but there will be ramifications, mistakes, and misuse. Our learned friends have a point. We have a powerful new tool—treading a little more carefully might be a good idea. **–CL**

> “ What held AI back was the scale to get it to work effectively. We have that now

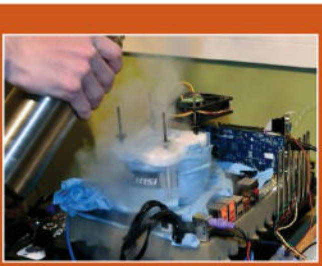
AMD TO GO HYBRID

Following in Intel's footsteps, AMD is using multiple cores

A KEY DIFFERENCE BETWEEN AMD AND INTEL is that the latter's processors have gone hybrid, with big and little cores sharing the work. AMD, on the other hand, has stuck with multiples of one core design. Both approaches have their strengths, but hybrid designs have some telling ones. AMD has a new APU chip code-named Phoenix 2 in development, which is expected to introduce us to AMD's version of the hybrid design with performance Zen 4 cores, and energy-efficient Zen 4c cores, each with hyper-threading. The chip reportedly has two big cores with 2MB of L2 apiece, and four little cores alongside an RDNA 3 integrated GPU. Rather than two architectures, the chip uses the same Zen 4 design for both jobs, adjusting clocks to suit the application: running at maximums of 4.8GHz and 3.0GHz respectively. We've no idea where this is going, but AMD is obviously ready to experiment. **–CL**

HOW TO KILL YOUR V-CACHE CHIP

AMD's new chip doesn't do well at high voltages



GIVE A HIGH-END PC user a fast chip and all they're going to want to do is try to make it go faster. AMD's V-Cache chips are a tempting target. However, there's a bug in some motherboard software (including from MSI, Asus, Gigabyte, and ASRock) that enables free control over voltages, and multipliers if you click through to 'Customize'. All safeguards are bypassed, and it is easy to fry the chip. High voltages produce too much heat, hence AMD's reduction of the maximum from 1.5v to 1.35v. You can also set the multiplier to 80. Theoretically: 8GHz. Reality: a fried chip.

Meanwhile, the Ryzen 9 7950X3D has been subject to some tweaking too, including a successful effort to 5.9GHz, thanks to AMD's PBO Curve Optimizer. Another effort was less successful, with a prominent YouTuber killing a new 7950X3D. Yes, you can overclock your V-Cache chip, but you will give it an a old-school edge. A fix for this bug is expected soon. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

✓ **CAR REPOSSESS ITSELF**
Ford has been granted a patent for a system that would let a car react to repossession: disabling features, and even driving away.

✓ **INTEL SHRINKS DRIVERS**
The launch driver for Arc graphics cards was 1.2GB. The new version has got it to 604MB.

✓ **ANCIENT MEATBALL**
Australian start-up Vow has mixed woolly mammoth DNA with stem cells to create a lab-cultivated prehistoric meatball.

TRAGEDIES

✗ **GAME KILLS CARDS**
Reports are emerging of RTX 3080 Ti cards getting trashed by *Diablo IV*. Advice so far is to cap the frame rate.

✗ **CHIP SMUGGLING FAIL**
A man was caught trying to get 239 Intel Core i5-13400F processors into China.

✗ **NVIDIA SLAMS CRYPTO**
The CTO at Nvidia has claimed that crypto adds nothing to society—apart from lots of money to Nvidia, obviously.

NEW GEFORCE CARDS THIS SPRING

Nvidia's mid-range cards finally ready

WE'VE BEEN WAITING for Nvidia's to flesh out its 4000-series cards for a while, but details are starting to land. The first to arrive is the GeForce RTX 4070, which according to a leak is April 13 (this should be confirmed by the time you read this). It uses the same AD104 silicon as the 4070 Ti, but cut down to 5,888 CUDA cores running at up to 2.475GHz. It carries 12GB of GDDR6 on a 192-bit bus offering a maximum data transfer of 504GB/s. All this will cost $599. The premium factory versions will be 225W cards, and use either the new 16-pin power connector, or two 8-pin ones. The standard cards will run at 200W, and stick to 8-pin connectors.

Next down the tree is the RTX 4060 Ti, due in May. The 160W card will sport a cut-down AD106 GPU with 4,352 CUDA cores coupled to 8GB of memory sitting on a 128-bit bus. The performance target is the old RTX 3070. The price is speculative, but if you were to guess $449 you wouldn't be far wrong. Leaked pictures purportedly showing a 4060 Ti have surfaced, and it's svelte compared to the high-end cards.

Then we have the RTX 4050, set for June. This is in the mid-range, with 2,560 CUDA cores with 6GB of RAM and a 96-bit bus. A price of $249 has surfaced, for which we can almost forgive the uninspiring specifications. Other rumors put it at up to $349, which we are less forgiving about, as it is going to struggle to play top-tier games at 1080p. This leaves the RTX 4060, but we've no release date yet. This is expected to run a full AD107 GPU with 3,072 cores. At 115W it might appear lightweight, but it's going to perform similarly to the 4060 laptop GPU, only with faster memory, so it'll be comparable with a 3060 Ti. This could be the range's sweet spot for 1080p gaming. **–CL**

Nvidia'S RTX 4070 will use the same AD104 silicon as the RTX 4070 Ti (right), but with less cores.

CONGRESS VS. TIKTOK

Could it actually be banned?

TIKTOK'S CEO, Shou Zi Chew, received a rough handling from a Congress committee recently. The nub of the matter was whether or not TikTok was a security threat, and if so, should it be banned. The trouble is that TikTok collects data, as does pretty much every company with an internet presence. However, TikTok is aggressive about it, and that data is available to the Chinese government. It doesn't really have a choice about this; it is part of Chinese law. The company has confirmed that personal data collected is available to staff in China, and that it has the data to spy on journalists as it tries to identify the source of leaks about the company's operations.

Can a ban work? Well, there are problems. There's the First Amendment, for a start, as well as other legal hurdles. Bills have been launched that would allow a presidential ban, one in the Senate, and one in the House of Representatives. It'll take co-operation and several months for either to succeed. Even if passed, it will require a lengthy review process. Factor in legal challenges, and you can add many more months. If Congress is serious about restricting TikTok then it is going to need to bring a bigger stick to this fight.

US companies have similar data stores on US citizens, and are not adverse to handing details over within legal parameters. Restricting access to a platform used by millions to spread their opinions isn't a good look. Congress is right about one thing, though: data given to TikTok is supplied to Chinese security forces. TikTok has earned bans in some countries, notably India, and been widely banned on government devices across the world, and in China for the same reasons. Free speech may defend it here, but has no chance in its homeland. **–CL**

Moore is no more

ONE OF THE PIONEERS OF THE PC INDUSTRY has passed away. Gordon E. Moore co-founded Intel in 1968, and was its CEO and chairman for many years. His contribution to the company was enormous, but his place in history is assured by an observation he made in 1965, published in *Electronics* magazine. He noticed that the number of components in an integrated circuit doubled every year, and speculated that this trend would continue for another ten. This became known as Moore's Law, although he never used the word 'law'.

In 1975 he throttled back, and postulated that after 1980 it would take two years to double. He was largely proved right. Ironically, this observation became the target for chip builders. It proved remarkably accurate, too. The prediction for 1975 was for a chip with 65,000 transistors, and Intel made one with 65,536. Whether or not Moore's Law still applies is moot, although some things have slowed down as we reach a number of limitations, including immovable ones such as atomic scale. It took until 2010 for it to slow, and by 2020 some claimed it was over, while others believe it to be alive and well. Mr. Moore's observation remains part of the industry's ethos. It provided an impetus for Intel, which became one of the most important companies in the world, involved in a business that changed the world. Moore's Law was, as the celebrated technology journalist Michael S. Malone put it, the metronome of modern life. He also claimed it as Silicon Valley's greatest legacy: a commitment to continual progress. Quite an achievement. **–CL**

Cheap DRAM

This summer might be the ideal time to fill out your memory slots. In the first quarter of the year, the average selling price of DRAM modules dropped by 20 percent, and indications are that by summer it'll fall at least another ten. This is the result of lower demand. Micron and SK Hynix (the second and third biggest manufacturers) have had to reduce production as unsold stock languishes in the supply chain.

Reports have it that there are enough PC DRAMs currently in stock to last between two to three months. Even demand from the traditionally memory-hungry server market is slow. Much of this excess stock is in the form of 8GB DDR4 modules, which isn't helpful either. Lowering production should stabilize prices, but it'll take until the fall before they firm-up, so it's not a bad time to start shopping for an upgrade. **–CL**

SK hynix
PLATINUM P41 NVMe

Steam to end Win7 support

On the first day of 2024, if you're running Windows 7 or 8, your Steam client will die. The reason cited is that it uses an embedded version of Chrome, and doesn't support Win7 or 8. Steam could have worked around this, but it seems it wasn't worth the effort. Win7 has proved remarkably sticky, holding onto ten percent of PC users for years. The end of the official security updates in February, however, was the final blow, and the number halved. Still, not bad for an OS launched in 2009.

How many Win7 systems are left depends on who you ask. StarCounter gives a figure of 3.72 percent, while Statcounter puts it a little higher at 5.34. Steam gamers tend to have newer systems, and it puts the figure at 1.52 percent, with another 0.34 percent using Win8. If that's you then it really is time to upgrade or lose your Steam access. **–CL**

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Jarred Walton

TECH TALK

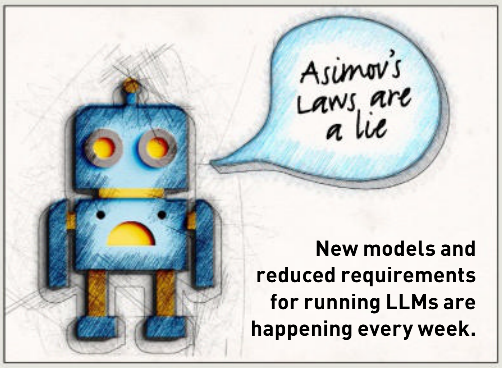
Running a "ChatGPT-lite" on your own PC

LAST MONTH, I QUIPPED THAT we're not yet at the point where you can run your own ChatGPT instance. While technically true, the amount of progress we've seen with different models and algorithms proves how short-sighted that statement was.

Much like Stable Diffusion last year, research in large language models (LLMs) means that you can now run your very own chatbot on your local PC. (https://tinyurl.com/local-chatbot) Caveats apply.

This isn't ChatGPT. You'll also want a GPU with as much VRAM as possible, and plenty of system memory—32GB is a realistic minimum. Nvidia GPUs are vastly preferable as well, which seems to be what 99 percent of AI researchers are using. Finally, given how much has changed in just a few weeks, don't be surprised if the gap between a locally running instance and ChatGPT narrows.

Over the past month, we've gone from needing an RTX 4090 for OPT-6.7b—Open Pretrained Transformer language model trained with 6.7 billion parameters—to being able to run a model with twice as many parameters on a 10GB GPU. Incidentally, the GPT-3 model used for ChatGPT was trained with 175 billion parameters. The reduction in requirements is thanks to loading the model first in 8-bit mode, and now in 4-bit mode, with the latter cutting memory requirements by 75 percent. While 4-bit versus 8-bit versus 16-bit might sound bad, for deep learning inferencing where the calculations often trend toward 0 or a large number, it apparently doesn't matter that much.


Asimov's Laws are a lie

New models and reduced requirements for running LLMs are happening every week.

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Getting the models running in less memory isn't the only change. GPT-3 wasn't necessarily trained in an ideal fashion, in part because what that might mean isn't entirely clear. Things keep getting adjusted, and a different model called LLaMa claims to deliver similar performance with just 7 billion parameters to what GPT-3 does with 175 billion. LLaMa-7b could already run on 24GB GPUs, but 8-bit mode enables up to the 13b model, and with 4-bit you can run the LLaMa-30b on a 24GB GPU.

8-bit and 4-bit effectively double and then quadruple performance, and that's in a relatively untuned state—a Core i9-12900K appeared to be the bigger limit on maximum throughput in testing, topping out at around 25 tokens per second. (Tokens are basically words, except symbols and other text elements can be present.) That's 1,500 words per minute, achievable on a 4090, 3090, or even a Titan RTX. Meanwhile, GPT-4 training is underway, apparently with 1 trillion parameters, though it supposedly will have similar hardware requirements to GPT-3.

Be warned that the output from these locally running chatbots feels incredibly dumb at times—much of the secret sauce that went into ChatGPT probably isn't present. If ChatGPT, Microsoft Bing, and Google Bart say some inappropriate things, what can be done with an unregulated locally running model is a different matter. One model was apparently trained on 4chan content, for example, and is available via BitTorrent. (Definitely NSFW!)

Also, new hardware is coming. Nvidia just announced its H100 NVL, a new dual-GPU variant of Hopper in PCIe format, with 94GB of HBM3 per GPU, compared to the 80GB on previous H100 models. With two cards communicating via triple NVLink connectors with 600 GB/s of bandwidth, you have a 188GB solution that could theoretically run in a server — more than enough for LLaMa-135b.

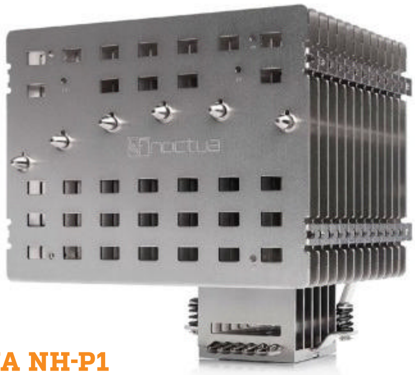
Not that you'll be able to buy the H100 NVL for home use. The H100 PCIe model with 80GB HBM2e is mostly available through workstation vendors, but we found at least one site selling a card for around $28,000. The H100 NVL comes as a 2-pack solution, and with more memory, faster memory, and higher performance, don't be surprised if some place lists it for $80,000. This is why so many AI researchers are apparently opting for RTX 4090 cards instead.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

THE LIST

THE TOP FIVE CPU AIR COOLERS

WE KNOW, WE KNOW—when it comes to CPU cooling, we tend to point you towards an All-In-One (AIO) liquid cooler. But the truth is there are highly capable chip chillers out there that solely rely on fans and heatsinks, even for overclocked processors. There's a lot to be said about the efficiency, affordability, and minimal fuss of a great CPU air cooler, so we've put together a list of the best air coolers to help keep your processor running smoothly.



5

NOCTUA NH-P1

The NH-P1 is a niche product, but it will satisfy that niche to perfection. It's expensive, bulky, and generally limited to CPUs in the 65W range. But it's also a passive cooler that's completely silent. That's what makes it a big deal. The NH-P1 is a great match for something like an AMD 5700G, with which you could omit a discrete GPU and play eSports titles in complete silence. **www.noctua.at, $110**

4

CRYORIG C7

If you're building a tiny PC, this is the low-profile cooler for you. It's just 47mm thick and adheres to strict 'keep-out' zones, meaning it won't interfere in any way with other system components. The C7 destroys the stock Intel cooler on performance and is rated for up to 100W, so is ideally suited to 65W class CPUs of up to about six or eight cores. Just don't put it on an overclocked or high-core count processor. **www.cryorig.com, $30**

3

NOCTUA NH-D15 CHROMAX

This is considered by many to be the best air cooler on the market. It performs brilliantly and has excellent fans fashioned in an attractive black color. Under normal operation, the NH-D15 can be considered truly silent. If you want an air cooler that can handle any consumer CPU on the market, then you might find one to match the Noctua flagship, but you won't find anything that truly beats it. Only 360mm AIO coolers outperform it. **www.noctua.at, $110**

2

BE QUIET! PURE ROCK 2

As the name suggests, the Be Quiet Pure Rock 2 really is quiet. It's equipped with the company's Pure Wings 2 PWM fan, which carries a low 26.8 dB(A) noise rating. It feels really solid, too—an indicator of good build quality—and it comes in at a low price. The aluminum finish is not a good-looking unit, so if you have a windowed case, consider this sleeker black version. Otherwise, it will cool out of sight, mind. **www.bequiet.com, $35**

1

DEEPCOOL AS500 PLUS

The AS500 Plus can compete with any single tower cooler on the market, but the key is that it undercuts them in price. The other contributors to its position atop this list are its excellent cooling and low noise levels, a great build quality, and subtle ARGB – it even comes with its own ARGB controller, and there's a white version too if you like. This is the cooler to get for all but the most high-end CPUs. **www.deepcool.com, $60**

© NOCTUA, CRYORIG, BE QUIET!, DEEPCOOL

Jeremy Laird

TRADE CHAT

It's simple, Intel's Meteor Lake is a mobile chip

A DISCLOSURE. I don't just enjoy the tech rumor mill, I'm involved in it. It's fun to track upcoming chips from Nvidia and Intel as they progress from mere whisper to retail reality. But as a journalist, you're only as good as your next rumor, which is why things can get a bit silly sometimes.

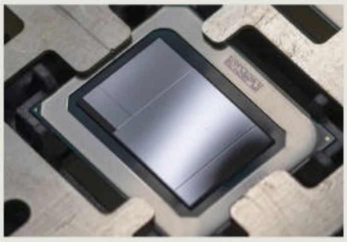
That's exactly what's happened with the rumors revolving around Intel's upcoming desktop Meteor Lake CPUs. But actually, it's simple. Meteor was probably never meant to be a desktop processor. That Intel's Meteor Lake processors exist is far from a secret. It is mentioned by senior Intel suits every time the company updates the markets on its progress. Meteor Lake, we are assured, remains on track for production later this year.

Meteor Lake will be its first consumer processor to use chiplets or, in Intel parlance, tiles. It will be four tiles: one for the CPU cores, one for the integrated GPU, an SoC tile, and an IO tile. It will also be the first CPU on Intel 4, the upcoming process node formerly known as 7nm. This is all public information, as is the fact that Meteor Lake's graphics tile will be manufactured by TSMC.

Where the silly season rumors come in involves the specifics around Meteor Lake's core counts and the exact SKUs it will be available in. The first big controversy around it was a rumor claiming that it will be limited to just six performance cores. That's fewer, notably, than both Alder Lake and Intel's incumbent CPU architecture Raptor Lake.

Only six big cores? What was the company thinking? This obviously meant that Intel 4 was a disaster and Intel's plans in tatters. After all, it turns out that it's not even good enough to produce a CPU with eight performance cores. Then came a rumor that Meteor Lake was in such bad shape that the desktop variant, Meteor Lake-S had been cancelled altogether. What a catastrophe.

> All the guff about cancellations and downgrades is just the internet getting wound up about nothing



What? It's only got six big cores? Everybody panic!

© INTEL

Except, that's likely all wrong. Or rather, it's a misinterpretation. It's more likely that Meteor Lake has always been targeted at mobile platforms. Indeed, Intel has form when it comes to rolling out chips on a new production node for mobile first. It's remarkable how quickly everyone seems to have forgotten Ice Lake, Intel's first 10nm CPU, which was mobile only. Indeed, Tiger Lake, Intel's second 10nm architecture, was mobile-only too. And both Ice Lake and Tiger Lake had fewer cores than Intel's desktop CPUs at the time.

Wind back to Intel's 14nm node and the first 14nm CPU was the Broadwell mobile chip. Okay, Intel later released a few Broadwell desktop SKUs, but it was primarily a mobile processor. As is often the case, rumors around Meteor Lake are connected to reality. It probably will be limited to six performance cores, and there probably won't be a desktop variant. But that's likely because that's what Intel intended.

So, Meteor Lake will be the first Intel 4 processor and for laptops only. It will be followed by Arrow Lake, which is closely related, but actually designed for the desktop. All the guff about cancellations and downgrades is just the internet getting wound up about nothing.

Anyway, the rumor mill will grind on regardless. Alongside Meteor Lake, there's Intel's supposed Royal Core, a mystical architecture due several years hence that's said to deliver unprecedented architectural and performance improvements. It's very much a staple topic of the tech chatterati, but it has never appeared on an Intel roadmap and can be traced back to a single source with a hit-and-miss record when it comes to leaks and rumors.

But where's the fun in acknowledging any of that when you can turn a single mention of an unconfirmed Intel CPU architecture into a series of high-traffic YouTube exposes? It's just so silly, but I can't deny it's fun.

Six raw 4K panels for breakfast, laced with extract of x86... Jeremy Laird eats and breathes PC technology.

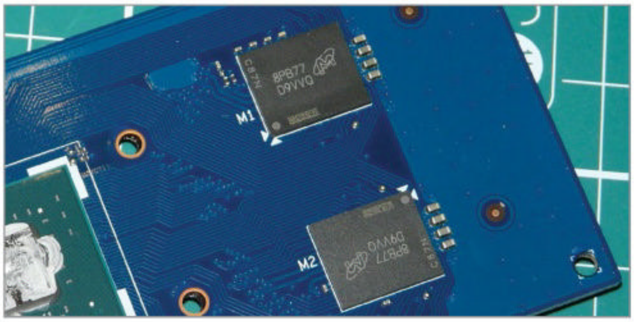
DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> How much VRAM?
> Taskbar icons AWOL
> Keep in sync

Video RAM question

Back in the early days of the RTX 3060, I remember a question about the amount of video RAM available and I believe you stated that 2GB would be plenty. Now, these cards are available with 12GB of video RAM! Why is this necessary and what has changed? **—Serpent Lord**



You'll need more than 2 GB VRAM for gaming.

THE DOCTOR RESPONDS: It's a good question, particularly given the huge amounts of system RAM available in today's PCs. But the answer is straightforward and based on the simple fact that VRAM is optimized for the demands of graphics. The type of RAM—GDDR SDRAM—is optimized for high-bandwidth usage, and along with its placement on the GPU, means it processes graphics far quicker than using system RAM.

As you'd expect, VRAM is used primarily to store and transfer the data needed to render gaming images in all their glorious color and resolution. If you're not a gamer or don't care for the latest high-res graphics, then 2GB is fine (this may be why we recommended this figure in response to a non-gamer's question), but as a rule of thumb, you'll need a minimum of 4GB for 1080p gaming, and 6 to 8GB for 1440p or 4K.

Why is this? Over the past few years, no doubt fueled by the availability of ever greater amounts of VRAM, developers have focused on producing graphics containing staggering amounts of quality and detail, and those demands on gaming textures and anti-aliasing, to name just two elements in rendering graphics, have forced requirements upward.

That said, don't fixate too much on memory—more VRAM doesn't necessarily mean a card will perform better than another one offering less. For example, AMD's budget RX 5500 XT doesn't render 1440p graphics better than NVIDIA's GTX 1660, even though it offers 8GB RAM to the GTX 1660's 6GB.

Clone or image?

A long time ago, I used Acronis True Image to back up my hard drive. I no longer go this route since when I needed to restore my computer, the backups were corrupted. Now for two desktops and two laptop computers, I simply buy an extra SSD drive, clone to it, then restart with the clone to verify it works (yes, I must boot to the BIOS and select the new drive). I then unplug the original drive and save it for any disasters. For the laptop, I use an M.2 to USB-C adapter that's cheap.

Not only is cloning faster than making a compressed backup, but backup programs slow down the computers. I now have a new Dell laptop with Windows 11. Could you consider reviewing a few cloning programs so I can pick a good one. **—Dave Shaff**

THE DOCTOR RESPONDS: Thankfully, the Doc can meet your requirements while extolling the virtues of image-based backups in a single answer. Any good backup program will offer an option to verify drive images—including True Image, which can be configured to automatically validate images once made (the equivalent of booting from your SSD clone).

Some imaging tools, most notably the Doc's favorite Macrium Reflect Home ($140 for a four-PC license or $70 to cover just one PC, www.macrium.com/products/home), can also be instructed to lower their CPU usage to make the backup process less intrusive on your day-to-day computing. Macrium users will find this option under 'Other Tasks > Edit Defaults and Settings > Advanced Settings > Priority', for example. Remember, your

↘ submit your questions to: doctor@maximumpc.com

PC only slows down while the backup is being taken, which is true for drive cloning too.

The benefit of image-based backup over cloning is that it supports incremental and differential backups. Once you have a full backup, subsequent ones are much quicker to make—and that includes drive cloning. Macrium Reflect Home supports both types, as does the freebie Hasleo Backup Suite (www.easyuefi.com).

The Doc recommends storing at least two copies of a backup in separate locations, so rather than invest in more SSD drives, why not combine the two methods? Both Macrium Reflect and our new freebie of choice support disk cloning as well as imaging.

This means you can enjoy the best of both worlds in one package—have regular image-based backups made automatically to a centralized backup location to provide a recent backup, then periodically clone your PCs to the dedicated SSDs you bought for redundancy.

Missing Taskbar icons

After I installed the Windows 11 22H2 update, some of my Taskbar icons were replaced by placeholders. Interestingly it was only the ones for Windows applications such as Calculator, Store, and My Phone. The icons show up elsewhere on my system and the Taskbar placeholders work when I click them, but I don't always know which is which. I've tried several 'fixes' such as deleting the icon cache, but none have worked. Any suggestions?

—Ned Weinshenker

THE DOCTOR RESPONDS: You're not alone in having this problem, Ned. The web is full of people reporting the same symptoms along with many suggested solutions. Many report the problem only occurring after waking from sleep, at which point, restarting the Windows Explorer process from Task Manager seems to 'fix' the problem—until it happens again. Others suggest simply opening the program from its placeholder icon refreshes the icon but, again, only temporarily.

The problem appears to affect apps installed through the Windows Store—that they're all Microsoft is coincidental. You could try opening the Store, selecting Library, and seeing if any updates are available. Try one or two, and if they fix the icon problem, click 'Update All' to fix the rest. Also, try removing and reinstalling the app to see if it fixes it.

Given the ongoing nature of this problem—even full-blown reinstalls have failed in some cases, suggesting the problem remains Microsoft's to fix—the only workaround the Doc can offer is to either remove Windows Store apps from the Taskbar altogether (pin them to the Start menu instead) or replace the Taskbar with a third-party alternative, like the free version of Winstep Nexus (www.winstep.net/nexus.asp).

Block unwanted popup

I've installed the free version of IObit Driver Booster on my system, diligently avoiding all its efforts to install additional software. Now, I keep getting an annoying popup from IObit trying to get me to install iTop VPN. It's bad enough that it appears, but there's no apparent way of closing this window, short of ending the process in Task Manager. How can I rid myself of this popup without removing Driver Booster?

—George J Hampton

THE DOCTOR RESPONDS: If you look carefully in the top right-hand corner, there's a close button, practically invisible to the naked eye (roll your mouse over this area and look for the 'Close' popup to appear, then click). Sadly, there appears no way to stop this popup (SafeTips.exe) from appearing, even when disabling the update checker in Driver Booster.

This leaves George with a simple choice: put up with the occasional popup (particularly now he knows how to close it) or consider switching to another driver updater tool. Snappy Driver Installer Origin (www.snappy-driver-installer.org) is free, open-source, and has no popups, although the user interface is chaotic and your security tool (particularly Malwarebytes) may flag certain IP addresses as containing trojans. That's because Snappy Driver uses peer-to-peer (p2p) networking to speed up downloads—the files it downloads are perfectly safe, however, and the warnings can be ignored.

Backup query

I have a backup software question for a particular need. I have multiple Synology NAS devices, each set up for a specific storage need (files, photos, video, and computer backup images). Whenever I leave town, I pull out one of the two RAID-1 drives from each NAS to store at an off-site location for safety. This is cumbersome but I don't want to use cloud storage because of the amount of data and cost involved. However, I do have one NAS device with two 20TB drives that should hold everything I need to act as redundant storage for all the others.

Is there any software I can install on one of my PCs that can be configured to store only specific directories from each of my NAS devices on this single 40TB NAS? And can it be used to scan for changes and only update them (like Documents-to-Go does between my iPhone and my PC), so I'm not doing a complete backup every time I move a folder from one NAS to another?

—Nick Kambouris

THE DOCTOR RESPONDS: This sounds like a job for file-sync software, Nick, and although Synology's own Drive software comes with ShareSync for keeping specific folders synced between one or more drives in your home, there's another option that won't tie you to Synology software, allowing you to employ it elsewhere.

That option is Syncthing (https://syncthing.net), which the Doc uses to keep all kinds of data synced between his computers, Ubuntu server, and failsafe QNAP NAS backup. Syncthing runs as a command-line daemon with a web-based frontend and it allows you to set up folder pairs between specific devices. You can have changes in one folder immediately synced to the other—or you can also set it to work one-way only, should you prefer.

Folder pairs can be between two or more devices, and files can be synced over your local network or the internet if required through secure (end-to-end encrypted) p2p connections, allowing you to take your 40TB NAS with you when you travel, or even house it in a secure remote location, with no additional configuration required.

Syncthing is available as an add-on through the Synology Package Center, and we recommend reading the app's documentation (https://docs.syncthing.net/) to see how it works and how easy it is to set up.

Everything is configured through your PC's web browser using the https://192.168.x.y:8384/ address (where 192.168.x.y corresponds to the IP address of whichever Synology NAS is currently being set up), and you can also install Syncthing on Windows, macOS, Linux and Android should you want to sync files from computer or mobile to your NAS drives.

BUILD A $942 GAMING PC

We dive into the Intel dimension to see if you can game on a budget at 1080p with the company's latest CPU and GPU offerings

Part	Make and model	Street price
Case	Corsair 275R Airflow Mid-tower ATX	$80
Mobo	ASRock B660M-ITX/ac Mini ITX	$120
CPU	Intel Core i5-13400F	$210
CPU Cooler	Intel Laminar RM1	N/A
GPU	Intel Arc A750 Limited Edition 8GB	$250
Memory	16GB (2x 8GB) ADATA XPG GAMMIX D45 DDR4-3200MHz	$50
SSD	1TB Samsung 970 EVO Plus PCIe 3.0 NVMe SSD	$70
PSU	NZXT C750 750W 80+Gold	$130
OS	Windows 11 Home 64-bit OEM	$32
Total		**$942**

IT'S THE ENDLESS POSSIBILITIES and customization options that draw us into PC building. You don't have to buy the latest components, and spending your budget wisely is ultimately what most of us are trying to do. Not only will this stop you burning a ginormous hole in your wallet, you won't spend your hard-earned bucks on just a few components. That said, while it's a great idea to decide what the most important components are, you don't need to dedicate the majority of your limit to those components.

In this sub-$1000 build, we wanted to use some of Intel's latest offerings, namely a 13th gen chip alongside an Arc graphics card. We've gone with Intel's Core i5-13400F and the Arc A750 Limited Edition 8GB. Both of these should offer decent longevity and provide plenty of support, but can be upgraded and swapped out later if needed. Seeing as we haven't done a cover build using both an Intel CPU and GPU, it'll be interesting to see where this system stands compared to Nvidia and AMD's alternatives, namely the Nvidia Geforce RTX 3060 and the AMD Radeon RX 6600. Is it worth going with a newer yet less experienced card, or sticking with the old but gold options?

As for the rest of the build, we spent wisely by not going overkill—okay, maybe the 750W NZXT PSU is, but there's a good reason. As this build has longevity and future upgrades in mind, 750W is good enough all the way up to an RTX 4070Ti. Not to throw shade on our A750, but that's quite the step up in performance, and could slot into this build later, once prices come down (hey, it could happen).

You may have also been wondering why we have an ITX mobo in an ATX case, and that is for the same reason—to save on budget. This motherboard was one of the cheapest we could find and was compatible with the rest of the system, yet we didn't want to restrict potential upgrades by keeping to the ITX format. This larger case allows for a new motherboard to enter the picture later.

That's the point here: you could take the budget and build a faster machine using an older socket set and GPU, but this could hinder you down the line and result in you needing to upgrade more parts than necessary. We've been sensible by using the LGA1700 socket with Intel's 13th gen CPU, plus Intel's latest budget GPU for a system that can hopefully give us a dependable 1080p gaming experience. Will this meet the mark or will we have to stretch our wallets further? Find out as we piece together this all-Intel adult Legos set. –SAM LEWIS

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Please type this URL into your browser if link is broken

STEP-BY-STEP
PG.22

INTEL CORE i5
i5-13400F
SRMBN
X238L871

CPU

INTEL CORE I5-13400F

Is this one of the latest and best mid-range gaming chips you can buy? Yes. With ten cores and 16 threads under its skin, it's not on the light end of the Intel 13th gen Raptor Lake scale. As we are using a GPU, we opted for this graphics-less version of the i5-13400, saying goodbye to the Intel UHD Graphics 730. This saved us around $20—sure, it's not the largest sum of money, but every little helps. The i5-12400 was an impressive chip last generation, so we have high expectations for this improved variant. Utilizing a hybrid architecture, it has six performance cores and four efficiency cores, and a max turbo frequency of 4.60 GHz. This should make for a dependable long-lasting captain of this noble ship.

• *$210* • *www.intel.com*

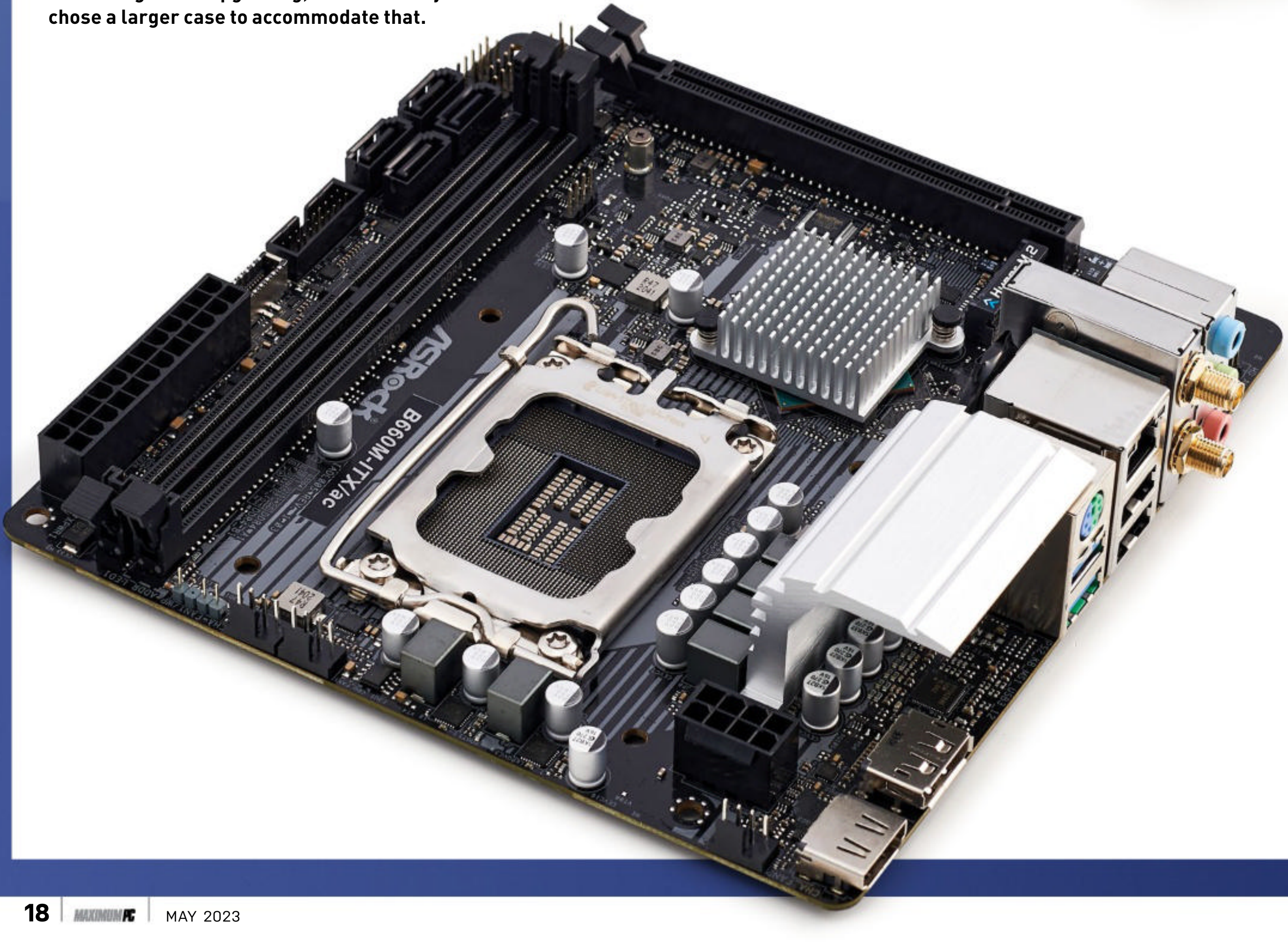
Motherboard

ASROCK B660M-ITX/AC MINI ITX

To house all of our components, we've chosen a board that we've used and liked previously: the B660M-ITX/ac Mini ITX mobo from ASRock. Sure, it's an ITX board, but it can support our 13th Gen Intel CPU and comes in at a low price of $120. It's DDR4, which is all we'll need for this specific system, but moving forward it will probably be something worth upgrading, and that's why we chose a larger case to accommodate that.

Unfortunately, stock is currently an issue. We managed to get a sample in time for the build, but afterward there appeared to be a backlog of orders. Alternatively, you could opt for the better-performing ASRock Z690M-ITX/ax LGA 1700 board for an extra $20.

• ***$120*** **•** ***www.asrock.com***



ARC A750
Limited Edition

STEP-BY-STEP
PG.22

GPU

INTEL ARC A750 LIMITED EDITION 8GB

Nvidia and AMD have been the two domineering GPU powerhouses for what seems like forever. However, with Intel stepping up to the plate by releasing the Arc range of graphics cards last year, a new competitor has entered the fray. Things didn't get off to a great start, with teething issues and sub-par performance, but with errors like driver problems smoothed out, these GPUs are now worth looking at.

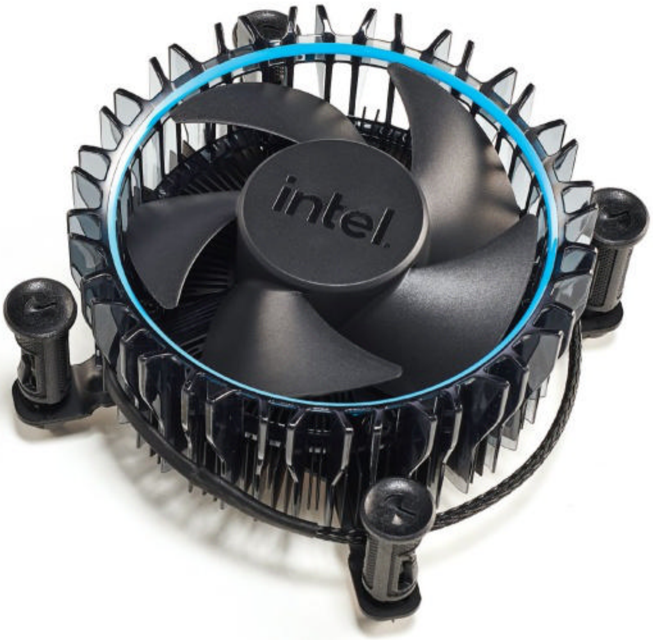
This A750 sits slightly below the king of the ring from Intel, the A770. It features 8GB of DDR5—which is more than enough for this power class—a clock speed of 2050 MHz, and a sleek high-end build quality. It's hard to directly compare stats across Nvidia, AMD, and Intel GPUs, but we're hoping that this Intel card can get us to Full HD gaming in modern titles.
• *$250* • *www.intel.com*

Cooler

INTEL LAMINAR RM1

Alongside our Intel Core i5-13400F comes this Intel 12th/13th gen stock cooler, the Laminar RM1. A far better-performing and looking stock cooler than previous generations, this saves us money as we don't have to buy another cooler. It's far better to go down this route if your GPU comes with a stock cooler and you aren't at the stage of overclocking, or if your build isn't running too hot. Then down the line, maybe after a few upgrades, it might be worth splashing out for an AIO to keep your system nice and cool.

The RM1 certainly ties in with the design of our A750 GPU—yes, it's fairly basic, but that's in its nature. It features pin clip connectors, so installing this is a breeze, requires no back bracket, has a good build quality (again like the GPU), and is up to 47mm in height, so we have plenty of clearance. This is more than good enough to stay in this system.
• *$N/A* • *www.intel.com*



STEP-BY-STEP PG.22

SSD

1TB SAMSUNG 970 EVO PLUS PCIE 3.0 NVME

Although not the snappiest of SSDs, with today's top-end drives achieving double the read and write speeds that this 970 EVO Plus offers, it's still a very dependable storage solution for our build. With 1TB capacity, we have plenty of storage to play with for games, productivity, creative applications and the scope for video editing. It features PCIe 3.0, so again, not the latest and greatest tech, but this drive is more than good enough for a budget-end rig like this. We should get sequential read/write speeds of up to 3,500/3,300 MB/s, and it's up to 50 percent faster than the standard 970 EVO SSD. For around $60, it's a great pickup from a tech powerhouse that has historically provided top-quality storage.
• *$60* • *www.samsung.com*

Case

CORSAIR 275R AIRFLOW

We've already mentioned this, but instead of keeping in line with the ITX motherboard and choosing a small form factor case, we've gone down the more generic route by allowing room for growth in our system. That meant choosing an ATX case, and one that came in at a low price while maintaining high build quality, good cable channeling and great airflow. So when looking through our stock room, the 275R Airflow stuck out as a case that achieves all of these factors. It has a striking ventilated front panel to allow air in while also looking clean and more expensive than its price tag entails. It's got rubber cable slots to channel the PSU cables through and one at the bottom, which is very handy for the GPU PCIe cables.
• *$80* • *www.corsair.com*

PSU

NZXT C750 750W 80+GOLD PSU

Powering our system is a slightly overkill power supply, but one that's well worth it. For future component upgrades, especially if you crank up your GPU, you'll need a PSU that can handle the larger power demand like this one. With enough power for an RTX 4070Ti, this has a healthy amount of headroom. Efficiency is also impressive, coming in at an 80+ Gold rating to help keep running costs down. As this is a light build and we aren't connecting up any SATA devices, we only need one CPU cable and one PCIe cable. This will help to keep the system tidy around the back of the PSU, too.

• *$130* • *www.nzxt.com*

RAM

16GB (2X 8GB) ADATA XPG GAMMIX D45 DDR4-3200MHZ

We've turned back the clocks and gone from recent builds featuring DDR5-5200MHz memory to using DDR4-3200MHz memory. On paper, this looks like quite the downgrade, yet in reality it's fast enough to cope with the kind of pressures a budget system like this will be under. We aren't exactly going to be shoveling bucketloads of high-intensity tasks onto this system or opening 250 consecutive Chrome tabs, so 16GB of 3200MHz ADATA XPG GAMMIX D45 fits the bill here. It has a robust and durable design that will last and supports Intel XMP 2.0 for easy memory overclocking, too.

• ***$50*** • ***www.xpg.com***

THE ALL-INTEL BUDGET MACHINE

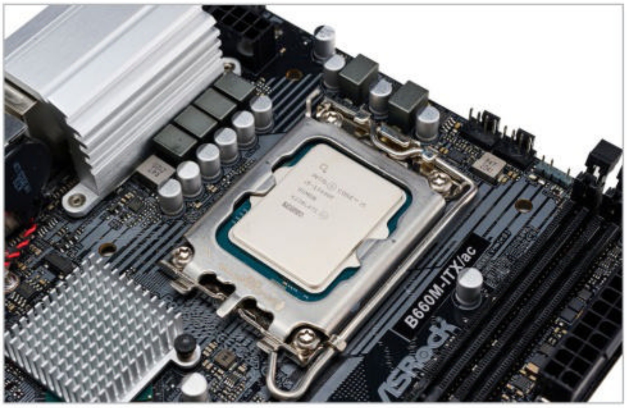
LENGTH OF TIME: **1-2 HOURS**
LEVEL OF DIFFICULTY: **EASY**

1 BACK TO BASICS

WE ALWAYS HAVE TO BEGIN our builds by focusing on what matters most: the chassis. In this instance, that's the Corsair 275R Airflow. To get to the nitty-gritty, we need to remove the panels, and for this case that's quick and easy. For the front panel, simply pull from the bottom to unclip it and then again from the top to pop it off. For the tempered glass side panel there are four thumb screws that are keeping it in place—just loosen these and keep them somewhere safe. Whenever taking the glass panel off a case, rest it on its back to avoid the glass panel slipping off—yes you guessed it, we've made that mistake before. Lastly, the back panel is held on with two captive thumbscrews, and when they're loosened, it slides off. With all the panels removed, we can start cracking on with this build.

2 HIGH-FIVE I5

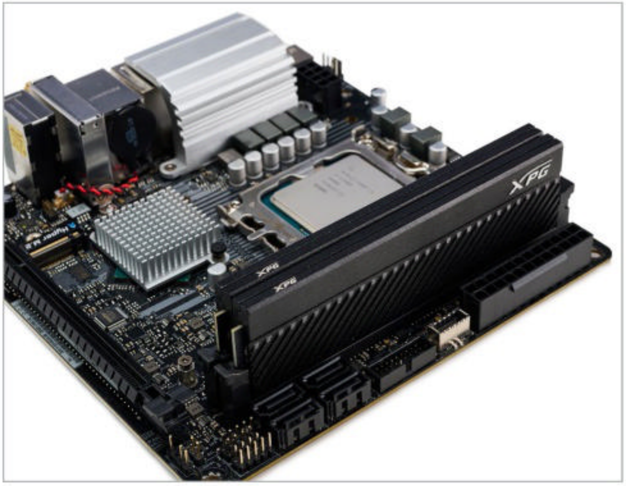
WITH THE CASE PUT TO THE SIDE for a moment, we bring our ASRock motherboard to the table, as well as our Intel Core i5-13400F. As this motherboard has been used before, it's important to make sure that the socket and the area around the socket are clean. Even more vital is that all the pins are straight and none have been bent. Luckily, there was no issue with this board, so we could crack on with installing the CPU. First off, lift the retention bar to the right of the socket to open it up. Then, on the socket, there should be an arrow—align this with the arrow on the chip and gently rest it down into the socket. Make sure you only hold it by the sides and never touch the bottom of the CPU. Once the chip has been inserted, lift up the retention arm once more and hook it back into place to lock it in.



STEP-BY-STEP

3 SWEET MEMORIES

WITH ONLY TWO SLOTS to play with, we didn't have to refer back to the motherboard manual to choose the correct DIMM slots to use with our two sticks of RAM. The only thing we had to do was align the notch in the slot with the notch on the sticks, unclip the slot, and then press the RAM into the slot. When you hear a loud and satisfying click, you'll know that the RAM has been seated correctly. We have to say, with the RAM in place, this motherboard is starting to look like a scaled-down dystopian model city, or maybe we're just going crazy! Now that our RAM is in place, we can move on to the SSD.



4 STORING THE STORAGE

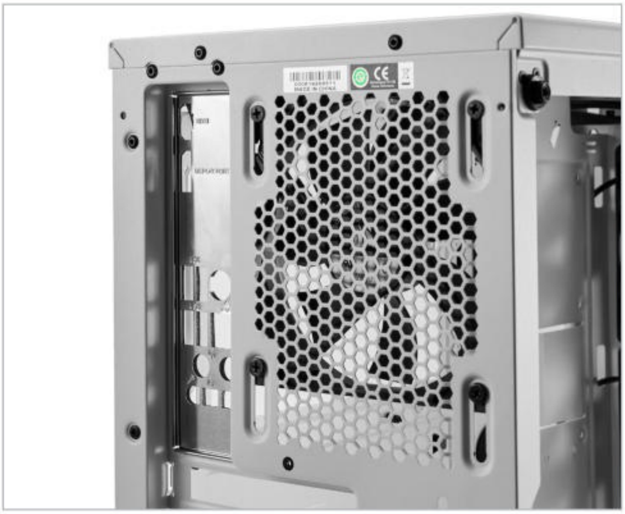
ONE ISSUE WE OVERLOOKED was with our SSD and its lack of a heatsink. Unfortunately, the motherboard didn't come with a heatsink cover either, so for the purposes of this build we had to go without it. Although not necessary, as SSDs don't typically get nearly as hot as HDDs do, we recommend using a heatsink on an M.2 drive. You can pick these up for around $10 on Amazon, which is what we did after the build was complete. Anyway, to install, remove the M.2 screw first, then insert the connector end of the SSD into the port, and push it down flat. Then you can use the M.2 screw to secure the drive onto the motherboard.

5 ICE COLD INTEL

THE LAST THING TO ADD to our motherboard at this stage is add the Intel Laminar RM1 stock cooler. Just like previous stock coolers from Intel, installation is easy—well, easier than a third-party AIO cooler. We positioned ours so that the cable was in the closest position to the CPU cooler header that it will connect to on the motherboard. Then, we applied a pea-sized drop of thermal paste into the center of our Intel Core i5-13400F and gently lowered the cooler on top making sure the clips on each corner dropped into the holes in the motherboard. With these in place, twist these clips and push them down to secure them in place.

6 I/O SHIELD

FOR NOW, our motherboard has all the components on it, besides the GPU, which we will install later, so it's ready for placing in the case. Our mini ITX board has a detachable I/O shield that needs to be inserted into the case first, though. This requires no tools; just to be pressed into position from the inside. Make sure it's the correct way up by checking the I/O ports on the motherboard first and then you can push it into the slot on the case. Go around the edges to make sure it's level and flush with the case, and we can then begin getting this board in position.



7 MOBO INSTALL

TO MAKE LIFE EASIER, rest the case on its back before attempting to install the motherboard into the case. Unlike a larger ATX board, there are only four case screws required to install this. Align the ports with the I/O shield first and then line up the screw holes on the motherboard with the standoffs in the case. With everything in position, tighten it down using a long and thin Philips screwdriver. A thin screwdriver is always best to use, as PC building can sometimes get fiddly as you add more and more components. There's still a lot of room left in this case after installing the motherboard, and although visually it may not be the best looking system we've ever build, we have room for improvement down the road.

8 POWER!

WITHOUT OUR NZXT C750 PSU, there's no way for us to get power to the system, so how about we get it installed? Before we do, make sure that any HDD cages in the bottom of the case are removed to make room for your PSU cables. Although not necessary, we aren't using a HDD, so we can put that aside for a rainy day for now. To install the PSU, make sure the fan is downward facing and align the screw holes on the PSU with the corresponding screw holes on the back of the case. Then, using four case screws, tighten the two together—it's as easy as pie! We only have to mention pie once and now we are hungry, brilliant.

9 CASE WIRES

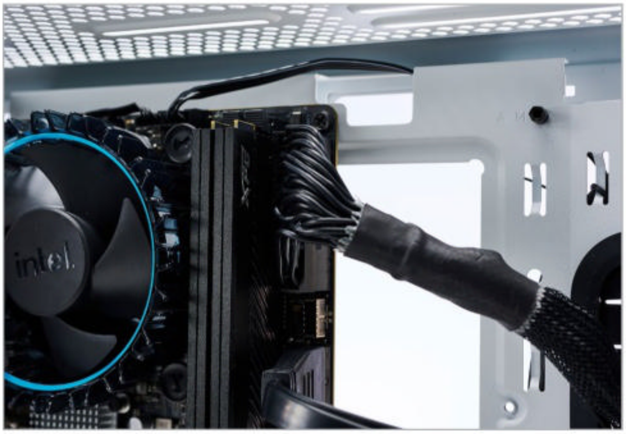
AFTER A QUICK BITE TO EAT, and after thoroughly washing our hands, we can start to connect up our case cables to the motherboard. One gripe with this case is the individual front panel connector pins—these have been and will always be a pain to install due to their fiddly nature. Luckily, we have plenty of space in this case to do so. Refer to your motherboard's manual to make sure you're installing the pins on the correct headers. It can take some time, and we certainly prefer it when these pins come as one header, but you win some, you lose some. We then installed the USB front panel cable to the motherboard—this port sits below the 24-pin motherboard connector.

10 FANTASTIC

BY USING A SMALLER FORM FACTOR motherboard such as this mini ITX ASRock model, you sacrifice headers and ports. For instance, when it came to connecting the fans to the motherboard, we soon hit an issue in running out of options, although a daisy chain connector soon resolved it. We connected one fan directly to a fan header on the motherboard, the other two used the daisy chain adapter and then that went into the other free fan header available. As we didn't enter destination RGB with this budget build, we didn't have to worry about a fan controller unit or excess RGB cables, so it kept our build nice and tidy.

11 SUPPLYING THE POWER SUPPLY

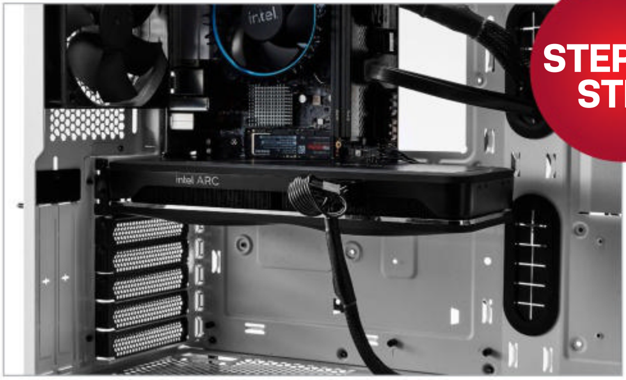
NOW WE HAVE THE CASE and fan cables linked up to the mainframe, it's time to supply power to the build with the PSU cables. As we mentioned earlier, there are only three cables, so this stage is fairly straightforward. Saying that, the CPU power cable is always awkward as it's in the top left of the motherboard tucked away in the corner. We managed to get this installed after some maneuvering, but if you know that this is going to be a tight squeeze, then you can always connect this first before installing the motherboard. The other cable we installed at this stage was the 24-pin motherboard cable through one of the case's rubber cable channels. As for the PCIe GPU cable, if you hadn't already noticed, there's currently no GPU, so we parked this one for now.



12 ENTER THE A750

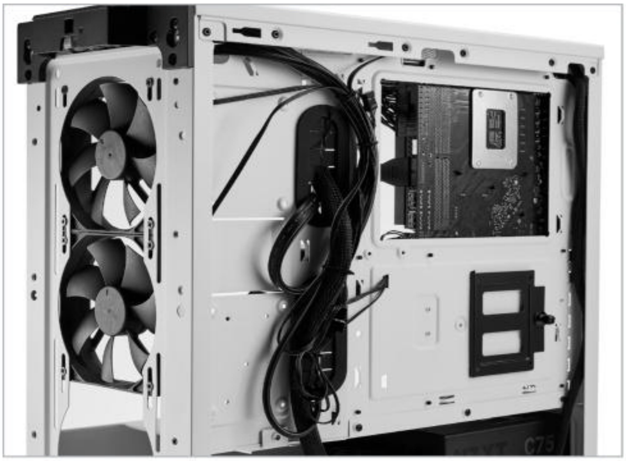
SPEAKING OF, we can finally install our Intel GPU, seeing as all of the cables are linked up. If we'd done this at an earlier stage, we wouldn't have been able to attach the individual pin connectors, as this A750 graphics card will block them. To install, make sure that the PCIe clip is opened up by pressing down on it. Also, make sure you have space where the PCIe shroudings sit. At this stage, all of ours had been removed before this build. We first aligned the PCIe connector to the slot on the motherboard and pushed it into position. This will reward you with a satisfying click to let you know it's been successfully installed. Then, using two case screws, we tightened the GPU onto the case, and installed the five remaining shrouds to the case to fill up the leftover space. The last cable to connect is the PCIe cable—we ran this through the bottom rubber access slot.

STEP-BY-STEP



13 BEHIND THE SCENES

TO KEEP THE FRONT AS TIDY AS POSSIBLE, it's vital to keep all of your cabling in check around the back of the case. Thanks to Corsair's cable management system and a fairly lite build, that was easy to do with this setup. Throughout the construction, we made sure to loosely run our cables down the most efficient routes and try and keep them together. After booting the system up to check everything was connected properly, we can now use some ties to fully cable manage our PC before putting on all of the panels. Although this isn't necessarily visible, it's good to know that your PC is neat. With a few minutes spent here keeping things in check, your PC is now ready for a BIOS update and fresh OS.



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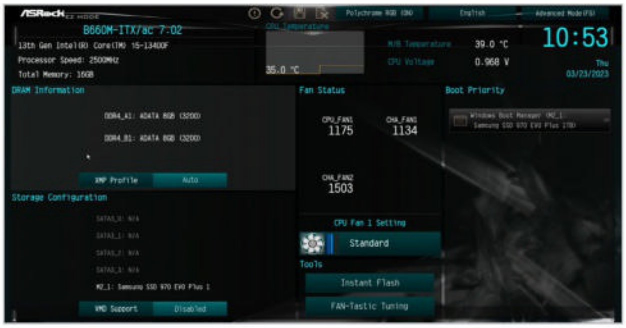
14 BIOS BONANZA

THINGS DIDN'T EXACTLY GO QUITE TO PLAN when booting this system up for the first time. It was stuck in a loop—however, we were one step ahead as we thought this could be an issue before building. We knew this motherboard was technically compatible with our 13th gen Intel chip—it just needed a BIOS update, but we thought we'd try our luck anyway. When that didn't go to plan, we had to use an Intel Core i5-12600K, a processor we knew worked with this motherboard, to boot the system with. Once loaded into the BIOS, we then had to use a secondary PC to download the latest BIOS driver from the official ASRock motherboard page, and installed this onto a clean FAT32 formatted USB drive. We then plugged this into the new build, loaded the system up again into the BIOS, then went to the Tools menu and selected instant flash. Here, it found our drive with the BIOS update on. Once this happens, click update and yes to confirm. Leave the PC alone while it updates.



B660M-ITX/ac 7.02
13th Gen Intel(R) Core(TM) i5-13400F
Processor Speed: 2500MHz
Total Memory: 16GB

CPU Temperature 35.0 °C
M/B Temperature 39.0 °C
CPU Voltage 0.968 V

10:53
Thu 03/23/2023

DRAM Information
DDR4_A1: ADATA 8GB (3200)
DDR4_B1: ADATA 8GB (3200)
XMP Profile: Auto

Storage Configuration
SATA3_0: N/A
SATA3_1: N/A
SATA3_2: N/A
SATA3_3: N/A
M2_1: Samsung SSD 970 EVO Plus 1
VMD Support: Disabled

Fan Status
CPU_FAN1 1175
CHA_FAN1 1134
CHA_FAN2 1503

CPU Fan 1 Setting: Standard

Boot Priority
Windows Boot Manager (M2_1: Samsung SSD 970 EVO Plus 1TB)

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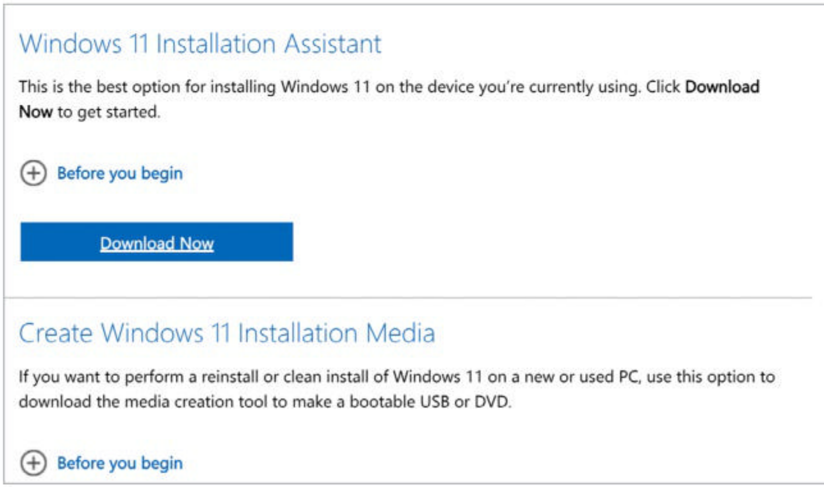
15 OUT WITH THE OLD (AGAIN)

ONCE THE BIOS HAS BEEN SUCCESSFULLY UPDATED, we can turn the system off and reinstall the Intel Core i5-13400F. Remember when doing so to always clean the old thermal paste off the previous cooler and the CPU cooler, then apply a new pea-sized amount in the center of the CPU. After the new chip has been seated back in its rightful position, we can start the process of installing Windows 11. Using a secondary PC/laptop again, go to the official Microsoft website and head to the Download Windows 11 page. Choose the 'Create Windows 11 Installation Media' option, install this, and then follow the on-screen instructions until it gives you the option of where to install.

Make sure you have a clean USB drive formatted to FAT32, like the one used to update the BIOS, and install it here. Once finished, insert this USB drive into the new PC, and load up the BIOS by mashing the DEL key on startup. In the BIOS, find the boot priority list and make sure the USB flash drive with Windows 11 installed is at the top, then save and exit. When you next boot the system it should then load the Windows 11 installation process. Follow this installation wizard and customize it to your liking.



Windows 11 Installation Assistant

This is the best option for installing Windows 11 on the device you're currently using. Click **Download Now** to get started.

Create Windows 11 Installation Media

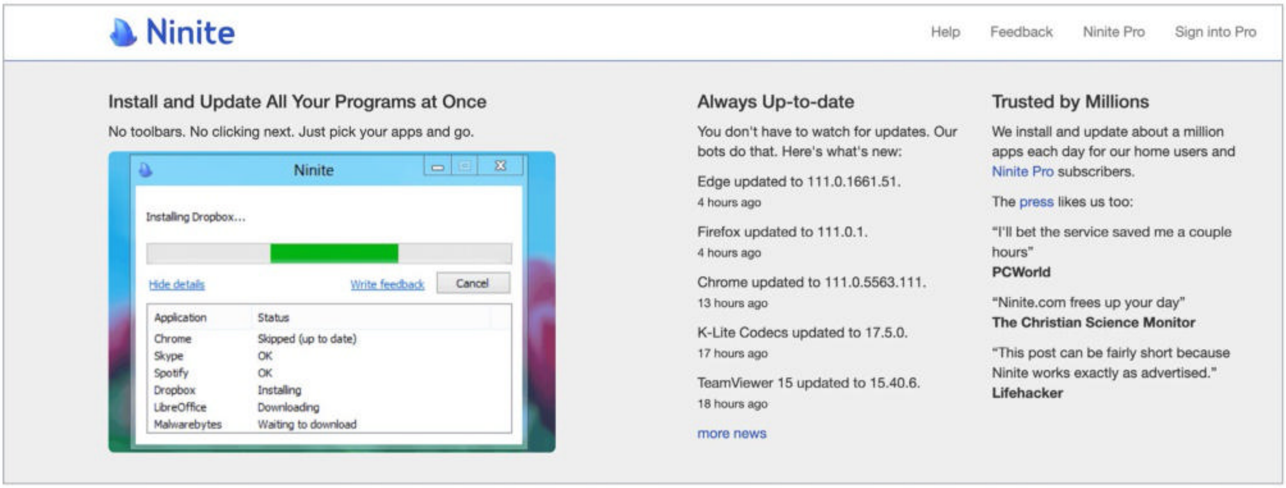
If you want to perform a reinstall or clean install of Windows 11 on a new or used PC, use this option to download the media creation tool to make a bootable USB or DVD.

STEP-BY-STEP

16 UPDATES & DRIVERS

ONCE ALL OF THAT HAS BEEN SORTED, you can start to enjoy the rest of your system. After you've connected it to the internet, the first thing to do is to install any Windows 11 updates and additional updates. This is easily found by heading into the settings and clicking on 'Windows Updates' in the bottom left-hand side of the Window. After this, you're going to want to install the Intel Driver & Support Assistant from the Intel website.

Here, it will automatically scan your system to detect if you need to update any drivers—most importantly, any Intel Arc graphic drivers. Install the latest to keep your system running at its best. This will ensure you're getting the best out of your components. It's only after this that you can start to install all of your favorite applications. A great starting point for this is ninite.com. On the website, it has a range of popular applications, utilities, creative software, security programs, and more to kit your new PC out. Check the boxes of the ones you want, and then underneath hit the big blue 'Get your Ninite' button. This will run an application that will install all of these apps at once. Trust us, it will save you a bunch of time. Finally, we can start having some fun with this new PC.



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Installing Dropbox...

Application	Status
Chrome	Skipped (up to date)
Skype	OK
Spotify	OK
Dropbox	Installing
LibreOffice	Downloading
Malwarebytes	Waiting to download

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You don't have to watch for updates. Our bots do that. Here's what's new:

Edge updated to 111.0.1661.51.
4 hours ago

Firefox updated to 111.0.1.
4 hours ago

Chrome updated to 111.0.5563.111.
13 hours ago

K-Lite Codecs updated to 17.5.0.
17 hours ago

TeamViewer 15 updated to 15.40.6.
18 hours ago

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A GREAT ALL INTEL STARTING POINT?

TO RECAP QUICKLY, this build had two mission objectives: to avoid breaking the $1000 mark and feature a current-gen Intel CPU & GPU combo. Considering that we almost always opt for an Nvidia RTX or an AMD Radeon RX card, it should be interesting to see how it performed and whether you should opt for a newer Intel card over an older card from Nvidia or AMD at the same price.

In short, both objectives were met. We even had $58 spare, so if we were to do this again, we could have added this to the motherboard budget to get an ATX board and a heatsink for the SSD. Regardless, the build went successfully, with only a few minor issues. For example, the lack of fan headers had us routing around for a spare daisy chain adapter. The case also had individual pin connectors for the power, which aren't always the most fun to install. These were located behind the GPU, which we initially installed first and then released afterward.

It's not the most eye-catching of machines, but that's the point in a way. This build was designed to have scope for component upgrades in future, while delivering a great value rig in the here and now. Sure, we'd have loved a more powerful motherboard with DDR5 support. But we were happy with the components, and our results from the benchmarking prove that 1080p gaming is certainly possible when using the Intel Core i5-13400F alongside the Intel ARC A750 GPU. Overall then, our system was running smoothly! Let's take a deeper look into our results.

BENCHMARKS

When pitted against a similar machine consisting of the same motherboard, the previous Intel i5-12400 CPU and a Zotac RTX 3050 with 8GB of GDDR6, this machine with the i5-13400F and the Intel Arc A750 very much impressed. Straight away, the Cinebench R23 scores show the advances over just one generation of upgrades for the processor. On the multi-core, we had an improvement of eight percent and on the single-core score we saw an improvement of two percent. Where our results took a hit was down to our PCIe 3.0 SSD, the Samsung 970 EVO plus. Although a very dependable drive, compared to the PCIe 4.0 Adata XPG GAMMIX S70 found in the other build, it was 50 percent slower. Saying that, the GAMMIX is a lightning-fast SSD.

Thankfully, our machine shone in the gaming department, where our Intel ARC A750 8GB took on the Zotac GeForce RTX 3050 Twin Edge 8GB. Similarly priced and both with 8GB of GDDR6 memory, there were improvements of up to 88 percent over the zero-point machine. Also, the 3DMark Fire Strike beat the previous machine by 73 percent. For the most part, this budget Arc A750 GPU has proved a good purchase for this price. Moving forward, a motherboard upgrade is due to improve compatibility and bring in DDR5 support. The same can be said for our SSD—although it's not a bad drive, it'd make a better secondary SSD and we could bring in a PCIe 4.0 SSD as our primary storage solution.

BENCHMARKS	ZERO POINT	
Cinebench R23 Single-Core (Index)	1,675	1,708 (2%)
Cinebench R23 Multi-Core (Index)	11,735	12,689 (8%)
CrystalDisk QD32 Sequential Read (MB/s)	7,100	3,552 (-50%)
CrystalDisk QD32 Sequential Write (MB/s)	6,755	3,302 (-51%)
3DMark Fire Strike (Index)	14,260	24,632 (73%)
Cyberpunk 2077 (fps)	49	92 (88%)
Metro Exodus (fps)	44	82 (86%)
Total War: Three Kingdoms (fps)	63	67 (6%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our 1080p zero-point consists of an Intel Core i5-12400, an Zotac GeForce RTX 3050 Twin Edge 8GB, an ASRock B660M-ITX/ac, 16GB of Corsair Vengeance RGB RS DDR4-3200, and a 1TB ADATA XPG GAMMIX S70. All games tested at 1080p 'Ultra' graphics presets with DLSS/FSR and V-sync turned off. XMP/AMP for RAM speed turned on in all tests. No manual CPU overclocking.

https://cdn.jwplayer.com/videos/01NwZno3-5NZ8MvJq.mp4
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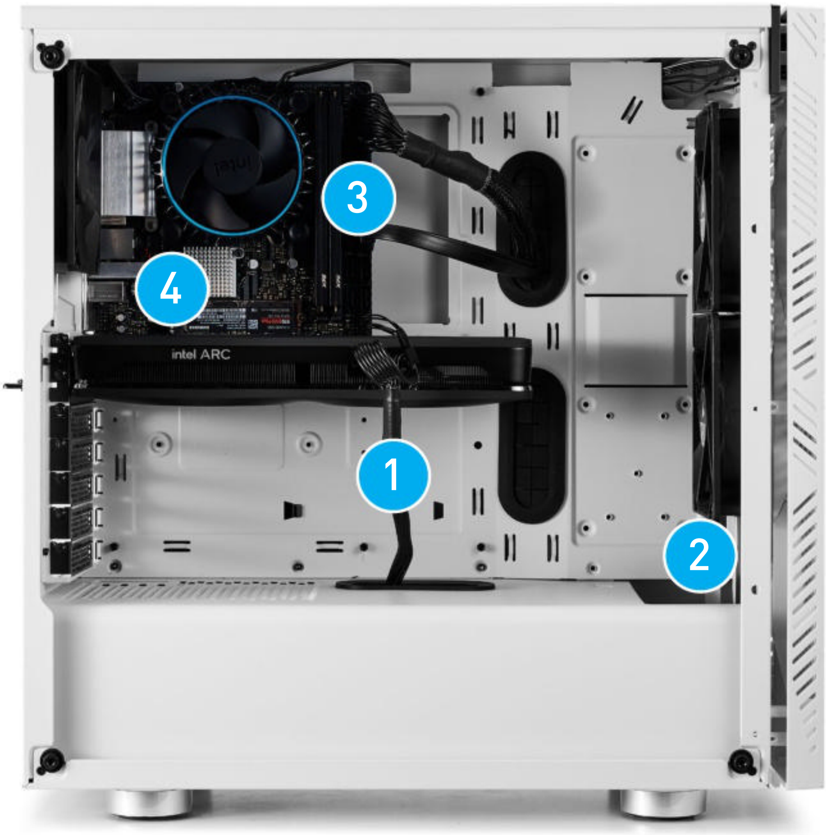

1 Our single PCIe cable for the ARC A750 isn't very pretty. With a neater custom cable here, it would look much better.

2 Moving forward, it would be a good idea to add another Corsair 120mm fan to the mix to increase airflow and complete the front end of this case.

3 The main thing to point out here is the sheer amount of space. Upgrades further down the line, such as a larger Z790 ATX motherboard, could fill this space up.

4 As we mentioned, our SSD had no heatsink at the time of building. We managed to add one after, though we'd rather play it safe and use one from the get-go.

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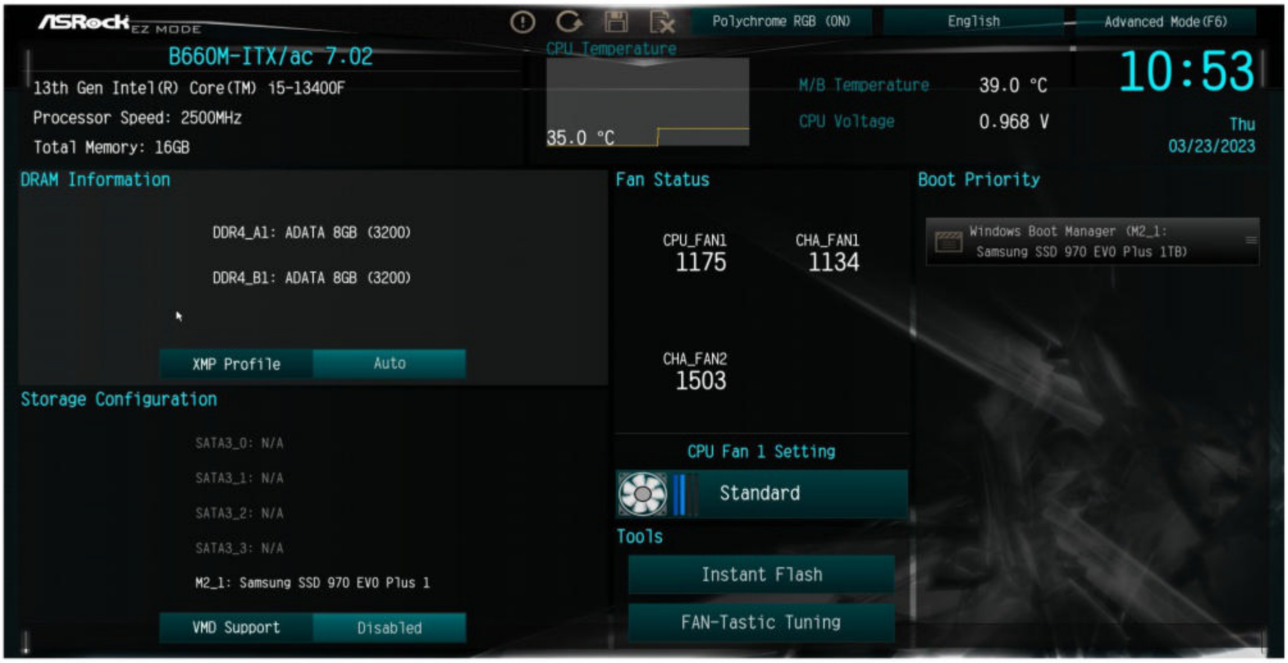

B660M-ITX/ac 7.02
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Total Memory: 16GB
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10:53
Thu
03/23/2023

DDR4_A1: ADATA 8GB (3200)
DDR4_B1: ADATA 8GB (3200)
XMP Profile: Auto

CPU_FAN1 1175
CHA_FAN1 1134
CHA_FAN2 1503

Windows Boot Manager (M2_1: Samsung SSD 970 EVO Plus 1TB)

SATA3_0: N/A
SATA3_1: N/A
SATA3_2: N/A
SATA3_3: N/A
M2_1: Samsung SSD 970 EVO Plus 1
VMD Support: Disabled

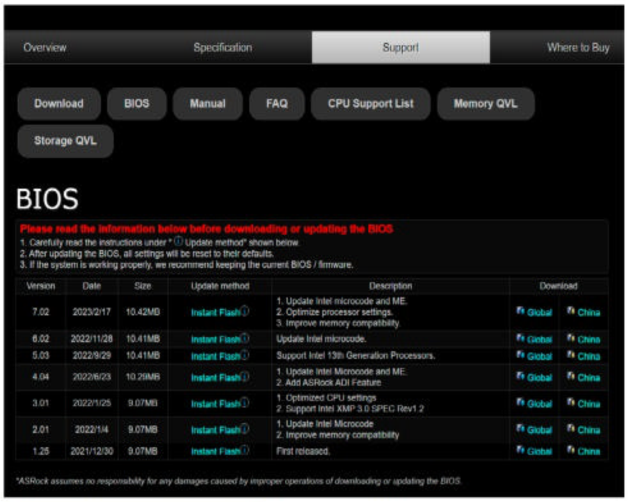
CPU Fan 1 Setting: Standard

A QUICK BIOS UPDATE OVERVIEW

BASICALLY JUST THE INPUT/OUTPUT SYSTEM. NO LITERALLY, IT IS

WHEN YOU'VE SPENT A LOT OF TIME and hard-earned money piecing together a PC that you've carefully planned out, it's important to know the ins and outs of your new machine. Much like anything else you've researched, saved up for and purchased, a PC isn't something to rush into, as you'll more than likely miss out on some important values and may not be getting the most out of your new pride and joy. One of the most vital elements of your PC to understand is the BIOS, short for basic input/output system. It's a piece of software that's installed onto your motherboard via a small memory chip, and allows you to set up the fundamentals of your PC. You can tweak fan, CPU and RAM speeds, boot priority order, date and time, voltage parameters, and much more. It's a rudimental piece of software, so don't worry when it loads and looks like something from the early 2000s running at around 20 fps.

After you power on your PC, it's the first piece of software that loads. It then runs a quick diagnostics test known as a POST (Power On Self-Test), which checks to see if there are any issues with your hardware—if there are, it won't load. This is where a more premium motherboard with an LED indicator or a beeping system can come in handy, as it can let you know what the error is. It's similar to when you get an EML (engine management light) to appear on the dashboard of your car. You can plug in a diagnostics tool and it will give you an error code, which you can then research further to get to the bottom of your issue. Our motherboard, the ASRock B660M-ITX/ac, is a budget board and unfortunately doesn't have the self-diagnostic features that a more expensive mobo has, so getting to the bottom of a POST issue is a little more complicated. It's always best to start off by updating your BIOS to eliminate any potential issues.



BIOS

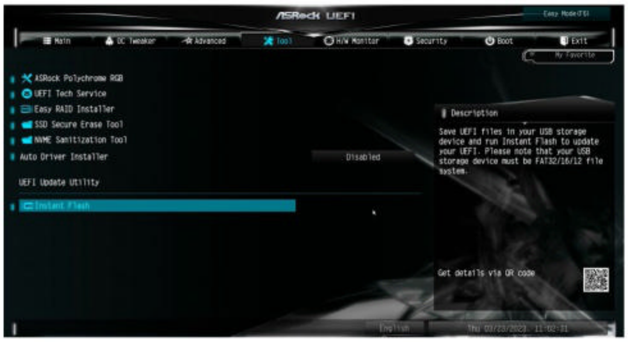
Please read the information below before downloading or updating the BIOS
1. Carefully read the instructions under " ⓘ Update method" shown below.
2. After updating the BIOS, all settings will be reset to their defaults.
3. If the system is working properly, we recommend keeping the current BIOS / firmware.

Version	Date	Size	Update method	Description	Download	
7.02	2023/2/17	10.42MB	Instant Flash ⓘ	1. Update Intel microcode and ME. 2. Optimize processor settings. 3. Improve memory compatibility.	Global	China
6.02	2022/11/28	10.41MB	Instant Flash ⓘ	Update Intel microcode.	Global	China
5.03	2022/9/29	10.41MB	Instant Flash ⓘ	Support Intel 13th Generation Processors.	Global	China
4.04	2022/6/23	10.29MB	Instant Flash ⓘ	1. Update Intel Microcode and ME. 2. Add ASRock ADI Feature	Global	China
3.01	2022/1/25	9.07MB	Instant Flash ⓘ	1. Optimized CPU settings 2. Support Intel XMP 3.0 SPEC Rev1.2	Global	China
2.01	2022/1/4	9.07MB	Instant Flash ⓘ	1. Update Intel Microcode 2. Improve memory compatibility	Global	China
1.25	2021/12/30	9.07MB	Instant Flash ⓘ	First released.	Global	China

*ASRock assumes no responsibility for any damages caused by improper operations of downloading or updating the BIOS.

DIFFERENT METHODS

Keeping your BIOS running on the latest firmware is as important as any other update on your PC. It can fix bugs and instability issues and improve compatibility with newer CPUs. We had this exact issue when using our ASRock B660M-ITX/ac. Although compatible with our Intel Core i5-13400F, this motherboard came out before the CPU, so needed updating to work with this 13th gen processor. There are a few ways to update your BIOS, so we will go over them starting with how we updated our ASRock B660M-ITX/ac to work with Intel's latest 13th-gen chips.



Save UEFI files in your USB storage device and run Instant Flash to update your UEFI. Please note that your USB storage device must be FAT32/16/12 file system.

1. FLASH UPDATE

Sometimes you have to take a step backward to move forward. In this instance, we couldn't boot our system using the i5-13400F, so we swapped the CPU back to an Intel Core i5-12600K that we had in our stockroom. We knew this was natively compatible with the motherboard, so we used this to get to the BIOS on our new build. As our system hadn't yet had an OS installed, on boot up it loaded straight into the BIOS, confirming that the motherboard and processor were compatible.

Now, using a secondary PC/laptop, you need to head to your motherboard's official website and find the exact product page for your board. Then, under the support page, you should find the BIOS section, in which you can download the latest update. Install this on a clean FAT32 USB drive and insert it into your new PC. Then, when you boot into the BIOS, head over to the tools section and find the 'Instant Flash' tool. Find the update file on your USB, select it and follow the onscreen instructions. This is what we had to do on our ASRock board—it varies slightly depending on which manufacturer your motherboard is, but fundamentally it is a similar process on other mobos.

Once you've got your new PC working, if a newer version of the BIOS releases, you can repeat this whole process, but you won't need an additional PC/laptop to download the latest BIOS file but you will still need to have a clean FAT32 USB drive. Again, head to the motherboard's official product page, and under the support section find the latest file, install and extract it onto the USB drive. Reboot your system, hit the delete key to open up your BIOS on boot up and repeat the process here.

2. BIOS FLASHBACK

On some motherboards, you can use a BIOS Flashback function. This is our favorite method of updating the BIOS, but it requires your board to have a BIOS FLBK USB port. It allows you to update BIOS without powering the system on, even without the need for a CPU. Not only would this have saved us time, it would also have been much easier to do. Again on compatible ASRock boards, download and extract the appropriate BIOS file and install it onto a clean USB drive formatted to FAT32. Rename this file "CREATIVE. ROM" and save it to the root directory of your USB flash drive.

Make sure your motherboard on the new PC has power via the 24-pin motherboard PSU cable, and press the AC switch. Insert the USB with the BIOS file into the BIOS Flashback USB port—it will be named on the motherboard's I/O panel. With it inserted, press the BIOS Flashback button for around three seconds, and an LED will start to blink. Leave this alone for a few minutes without turning off the power. When the LED stops flashing, the update has been completed. If you have another brand of motherboard with this function, the fundamentals are the same—just refer to your motherboard's official manual and product page to make sure you are following the correct instructions.

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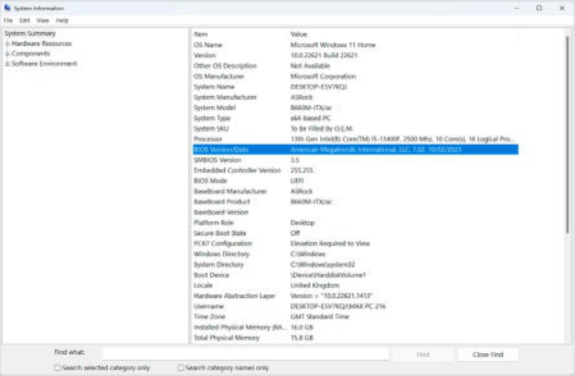
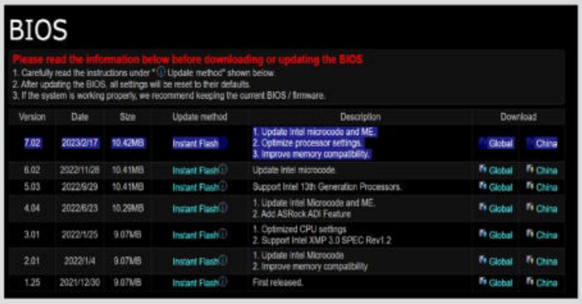
Check your BIOS version



Item	Value
OS Name	Microsoft Windows 11 Home
Version	10.0.22621 Build 22621
Other OS Description	Not Available
OS Manufacturer	Microsoft Corporation
System Name	DESKTOP-E5V7KQJ
System Manufacturer	ASRock
System Model	B660M-ITX/ac
System Type	x64-based PC
System SKU	To Be Filled By O.E.M.
Processor	13th Gen Intel(R) Core(TM) i5-13400F, 2500 Mhz, 10 Core(s), 16 Logical Pro...
BIOS Version/Date	American Megatrends International, LLC. 7.02, 10/02/2023
SMBIOS Version	3.5
Embedded Controller Version	255.255
BIOS Mode	UEFI
BaseBoard Manufacturer	ASRock
BaseBoard Product	B660M-ITX/ac
BaseBoard Version	
Platform Role	Desktop
Secure Boot State	Off
PCR7 Configuration	Elevation Required to View
Windows Directory	C:\Windows
System Directory	C:\Windows\system32
Boot Device	\Device\HarddiskVolume1
Locale	United Kingdom
Hardware Abstraction Layer	Version = "10.0.22621.1413"
Username	DESKTOP-E5V7KQJ\MAX PC 216
Time Zone	GMT Standard Time
Installed Physical Memory (RA...	16.0 GB
Total Physical Memory	15.8 GB

☐ Search selected category only ☐ Search category names only

To make sure you have the latest version of your BIOS, you can check this out on your system information page. To see this, head to the search bar of your PC and simply type in "System Information". Opening this up will reveal a plain looking window containing important factual information on your PC. On the system summary page, find the 'BIOS Version/Date' to identify your current BIOS. Ours is currently 7.02.



BIOS

Please read the information below before downloading or updating the BIOS
1. Carefully read the instructions under "ⓘ Update method" shown below.
2. After updating the BIOS, all settings will be reset to their defaults.
3. If the system is working properly, we recommend keeping the current BIOS / firmware.

Version	Date	Size	Update method	Description	Download	
7.02	2023/2/17	10.42MB	Instant Flash	1. Update Intel microcode and ME. 2. Optimize processor settings. 3. Improve memory compatibility.	Global	China
6.02	2022/11/28	10.41MB	Instant Flash ⓘ	Update Intel microcode.	Global	China
5.03	2022/9/29	10.41MB	Instant Flash ⓘ	Support Intel 13th Generation Processors.	Global	China
4.04	2022/6/23	10.29MB	Instant Flash ⓘ	1. Update Intel Microcode and ME. 2. Add ASRock ADI Feature	Global	China
3.01	2022/1/25	9.07MB	Instant Flash ⓘ	1. Optimized CPU settings 2. Support Intel XMP 3.0 SPEC Rev1.2	Global	China
2.01	2022/1/4	9.07MB	Instant Flash ⓘ	1. Update Intel Microcode 2. Improve memory compatibility	Global	China
1.25	2021/12/30	9.07MB	Instant Flash ⓘ	First released.	Global	China

Head to your specific official motherboard manufacturer page, then to the support section and under the BIOS, find the latest version—this should be the one at the top. As you can see, for us, on our ASRock B660M-ITX/ac, this is also version 7.02 so we currently have the latest version and there is nothing for us to update as of yet. If yours is out of date, install the latest to improve system stability.

SUMMARY

The BIOS is a fundamental part of your machine, and if you keep it up to date, understand the basics and use it to your advantage, you'll be able to get the most out of your new PC build. It's important for this build specifically, as we have designed this system with room for improvement. Even if we don't upgrade our motherboard and a newer CPU comes out that we want to add to the mix, we can update the BIOS to ensure the processor is compatible. Of course, always check the official motherboard site for compatibility first, but even if it does say it's compatible, it may still need a BIOS update, just as we encountered.

It's important to have a deep dive into your BIOS, too. Although it can look daunting and like something out of the Matrix, most systems have an easy mode view to make things more accessible. Have a look through this menu to get the most out of your components and to check if your hardware is running correctly. ⏻

THE FLAT PANEL PIPELINE

Jeremy Laird investigates flat panel technology and lifts the lid on what you can expect in the near and not-so-near future

BE CAREFUL WHAT you ask for—you might just get it. So it goes with screen technology of late. We've been clamoring for something better than an LCD panel with a big, dumb backlight for years. Now we've got it, and it turns out—in some ways, at least—that conventional LCD monitors aren't so bad after all.

The new entrants on the display scene are, of course, mini-LED and OLED. Mini-LED screens are actually a subset of LCD displays, not a new category of panel tech. But they do represent a significant step change. OLED, meanwhile, has taken its time transitioning from the TV market to PC monitors. But it is a radical new technology and has finally arrived in desktop monitors.

On paper, both offer dramatic advantages over conventional LCD displays. At last, you can have true HDR performance, per-pixel lighting, rapid response times and several other hitherto unobtainable screen attributes. In practice, however, they are turning out to be rather more problematic than predicted.

© UNSPLASH

Put it this way: we've seen numerous examples of the latest mini-LED and OLED monitors, and we're not sure we'd take any of them over the best available conventional LCD panels.

There are a couple of caveats to that, which we'll come to. But along the way, we need to identify what exactly the problems with mini-LED and OLED monitors are, ask if they can be fixed and consider if there are any alternative technologies that entirely sidestep all the issues. Let's get to it.

LCD, mini-LED or OLED—which deserves to be in your next monitor?

WE'VE MENTIONED THIS BEFORE in previous issues, but LCD is a fundamentally borked technology when it comes to displaying full color motion images. In fact, it's so bad that you have to give credit to the engineers who polished what is ultimately a flat panel turd into the dominant display tech it has become today.

So let's start by recounting the many ways in which LCD technology is unsuitable for use as a modern display solution for computing. For a start,, it's transmissive rather than emissive, meaning that you need a separate light source to push photons through the pixels.

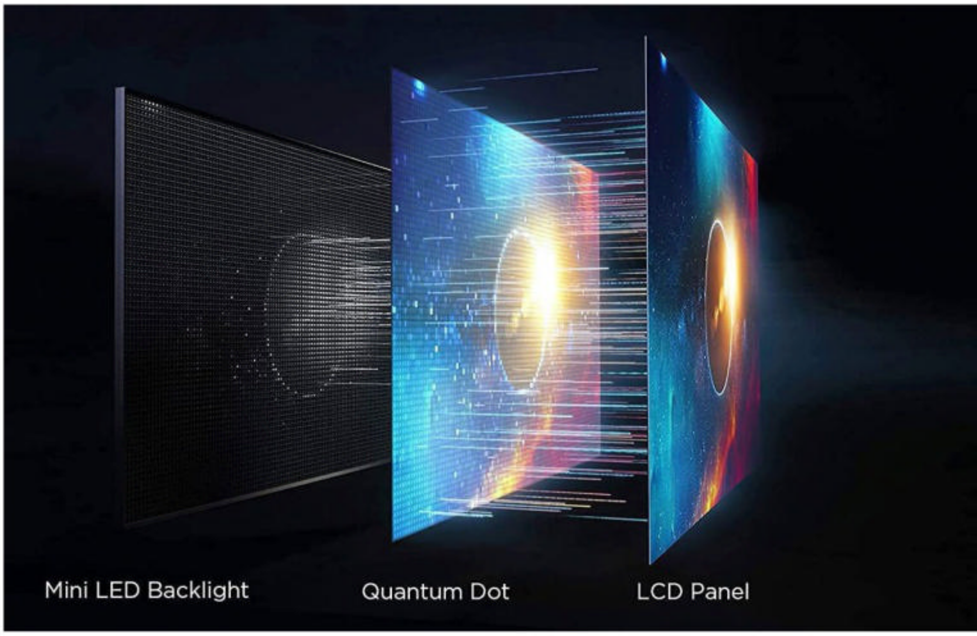
This is problematic on several levels. First, you have to choose between a single big, dumb backlight and something more complex that allows some kind of local lighting control. The more precise the local control, the more complex and costly your light source becomes.

Second, the idea is that the liquid crystals in those eponymous panels—LCD stands for Liquid Crystal Display—can change orientation and thereby control the amount of light that passes through a given pixel to be controlled. However, that control is imperfect.

On the one hand, that means a little light leaks through, even if you don't want it to. That's why conventional LCD panels have such poor contrast and black levels – it's that unintended light leakage spoiling everything. On the other, the physical characteristics of those crystals mean that the amount of light that passes through also depends on the angle at which you view them, so depending on where you are sitting in relation to the screen surface, the brightness and colors can change. Taken altogether, that means bad things for black levels, contrast and viewing angles.

Those liquid crystals have more to answer for, however. Because the technology involves the movement of physical crystals, that inevitably takes time. That's known as the response time, and it's much slower for LCD than a truly solid state technology like LED, which responds almost instantly.

These days, monitor makers claim LCD response times of 1ms or even 0.5ms. But those metrics are misleading and only measure part of the transition process from one color to the next. In reality, the full response time for even the fastest LCD panels is around 10 times slower—slow enough, in other words, that the response is detectable by the human eye in the form of blurring and smearing. That's true to an extent, even with the very latest and fastest LCD panels.



Mini-LED is still fundamentally a transmissive technology using LCD panels.

If those are the baked-in issues with LCD tech, the solutions are mini-LED and OLED—at least, that's the theory. Mini-LED isn't actually a brand new display tech, but really an improved backlighting solution for LCD panels. The way it works makes a lot of sense. Instead of a monolithic backlight, mini-LED is composed of an array of zones that can each be individually controlled. The idea of local dimming zones isn't unique to mini-LED, but mini-LED takes that approach and really runs with it. Currently, mini-LED monitors are available with as many as 1,000 or more zones, far more than previous local dimming applications.

The benefit of all those zones is the ability to adjust the backlighting to suit the image being displayed, so the zones behind bright objects can be ramped up, while those behind darker areas can be wound down, dramatically increasing contrast. It's even possible to achieve true black levels by switching zones off.

At least, that's the theory. In practice, mini-LED is still a pretty crude lighting solution. Take a 4K mini-LED monitor with 1,152 zones. The problem is that a 4K panel has over 8 million pixels, so each zone lights up 7,200 pixels. But the fine details in images might only be a few pixels across and involve maximum

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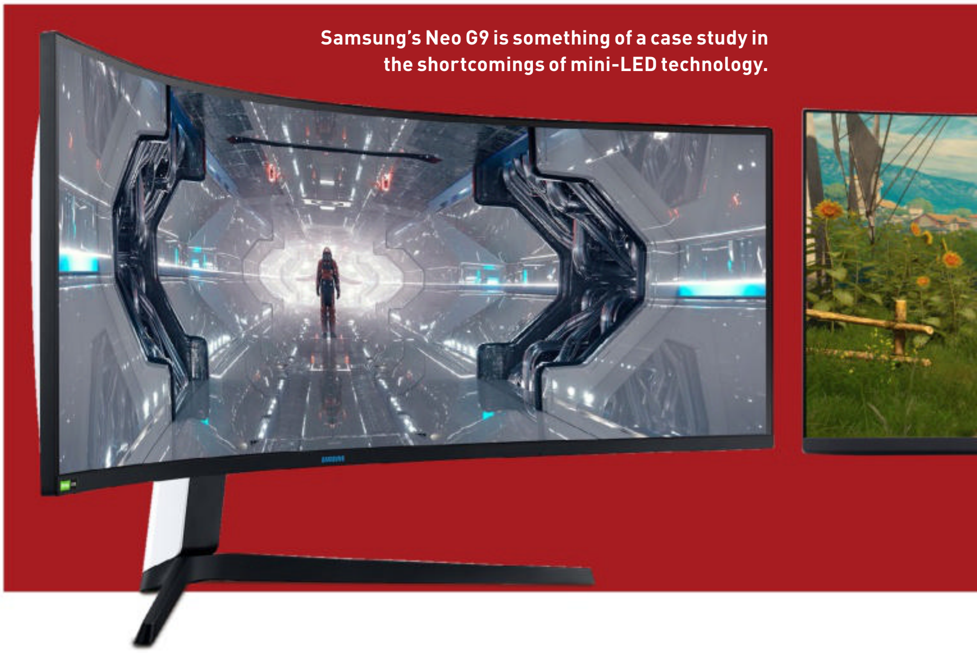

Samsung's Neo G9 is something of a case study in the shortcomings of mini-LED technology.

brightness next to completely black. An example is text, the lines and curves of which contain very small pixel counts.

Mini-LED has no good way of dealing with that any more than a panel with a single, monolithic backlight does. Even with thousands of zones, you're going to find that several words fit inside a zone. You're nowhere near being able to light up individual letters.

In practice, then, mini-LED has some major issues. On the Windows desktop, you get all kinds of oddities. You can see the zones popping on and off as you move windows and apps around, and visible lighting gradients are often visible across blocks of text if one side of the text is near a much brighter or darker screen element than the text itself is situated in. If it was a normal monitor, you'd think it was broken.

Admittedly, the problems are less obvious in games and movies, and the best mini-LED panels are capable of incredible brightness up to 1,600 nits or more. But the bottom line is that mini-LED panels involve compromises. The effective resolution of the dimming zones is so much lower than the image displayed that there are always trade-offs.

In games and video, that can mean a loss of detail in darker areas of rendered images as the zones behind them are turned down and the subtleties are crushed. Likewise, blooming around bright objects can also be seen as the zones are cranked up, but don't quite match the shapes of objects and text.

And of course, mini-LED does nothing to fix the response and viewing angle shortcomings of LCD technology. However, there is a panel technology that promises a solution to those things as well as avoiding the compromises of local dimming arrays. Yup, it's OLED and it fixes absolutely everything. Or does it?

The most obvious benefit of OLED is that it's an emissive screen technology. That means it doesn't need a backlight at all. Each pixel—indeed, each subpixel—is its own light source. OLED is the real per-pixel lighting deal. You can have a completely switched off, fully black pixel right next to one running at full brightness. No blooming, no trade-offs; just perfectly controlled contrast and true black levels.

As a truly solid-state technology, OLED is faster than LCD and can achieve true on-off performance well below 1ms. Most OLED monitors are quoted in the 0.1ms to 0.03 ms range, making them more than an order of magnitude faster than LCD. So that's it—OLED is the way, the truth and quite literally the light, right? Sadly not.

The best-known issue with OLED tech is image retention—or burn-in. The problem relates to the fact that the red, green and blue subpixels in an OLED panel wear out at different rates. The blue subpixels wear out faster than the red and green subpixels. Over time, that can cause the panel to lose overall color accuracy.

What's more, let's say the panel is displaying a pure green object at 500 nits. That will require 500 nits predominantly from the green subpixels. But a white object, also displayed at 500 nits, will use all three subpixels, sharing the load.

In other words, the wear rate on the subpixels varies according to the colors being rendered. If you render a bright blue object for an extended period, that's the worst possible scenario. If you display such a high-wear visual object on the screen for long enough, the pixels rendering it will wear more than others, and that can permanently shift their color balance compared to pixels around them, resulting in that image or object being "burned" into the panel permanently.

OLED technology has been developed over the years to reduce the risk of burn-in. Several mitigating technologies, such as image shift, have been implemented to the extent that burn-in isn't much of an issue for TVs. Image shift works by over-provisioning pixels or resolution such that the image can be shifted slightly across the panel without cropping the picture.

Almost all recent OLEDs have what's known as compensation cycles, also known as pixel refresh cycles. In simple terms, wear levels across the panel during normal usage are registered. The refresh cycles run at set time intervals, displaying image patterns that drive the pixels with colors that even out the wear.

Most screens have two different compensation cycles: a short one that runs frequently, typically every four hours or so, and a more intensive cycle that will run after 2,000 hours and takes longer to complete. Anyway, as a consequence of these measures, burn-in isn't a major problem with the latest OLED TVs. It's yet to be seen how well the new generation of OLED monitors will fare. We'll only know for sure how well panels in PC monitors last once they've been around for several years, but early indications are good.

Speaking of subpixels, another problem with OLED tech is subpixel structure. The vast majority of LCD monitors use the

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Alienware's 34-inch model is about as good as OLED gaming monitors currently get.

THE
WITCHER
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The Corsair Xeneon Flex is a 45-inch beast of an OLED monitor but suffers from pretty much all of the technology's shortcomings.

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THE ULTIMATE DISPLAY TECH

MICROLED HAS JUST ONE PROBLEM…

It's the perfect display technology. There's just one problem: you can't buy it, at least not in a form relevant to the PC. That's the problem with microLED—it may as well not exist unless you need a massive display for a public installation.

So why can't you get it in a PC monitor? First, let's review why you'd even want it. Like OLED, microLED is a self-emissive technology. Each pixel being its own fully switchable light source, so you can have a fully "off" pixel right next to one running at full brightness, giving perfect lighting control and effectively infinite contrast.

However, unlike OLED, microLED sidesteps the organic compounds that translate into so much pain when it comes to image retention and burn in. What's more, microLED might be even faster than OLED, which itself is at least an order of magnitude quicker than LCD.

At CES earlier this year, Samsung claimed that its latest microLED tech clocked in at just two nanoseconds for response time. That compares with the claimed 0.1ms pixel response of Alienware's 34-inch OLED gaming monitor, which of course uses a Samsung Quantum Dot OLED panel.

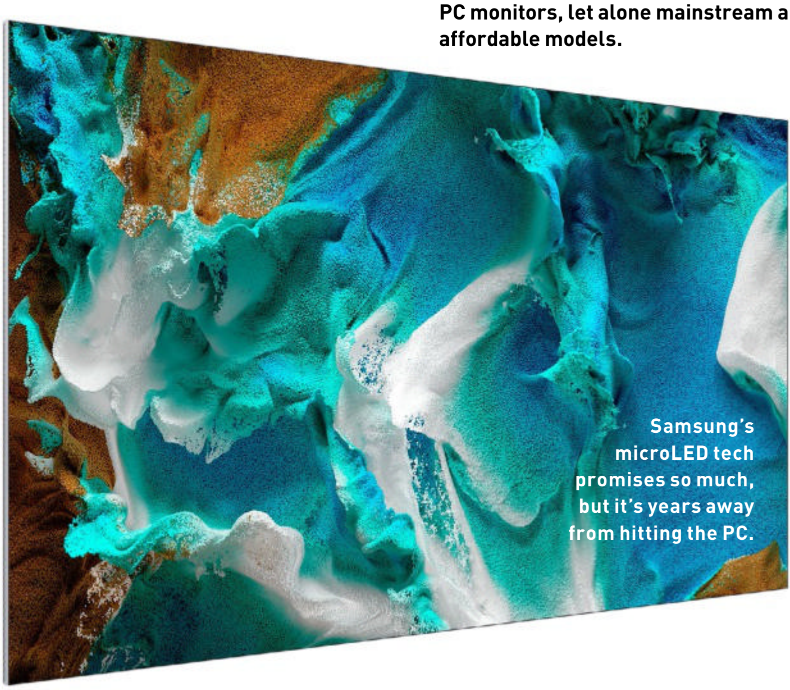
If nanosecond versus milliseconds doesn't mean anything to you, it's worth noting the gap between the two metrics. A millisecond is one thousandth of a second, but a nanosecond is one billionth of a second. That means Samsung is claiming its microLED panels are 50,000 times faster than its OLED panels.

So microLED sounds amazing, right? Indeed, but it's nowhere near appearing in PC monitors. The first problem is pricing—it's crazy expensive. That's because of current manufacturing techniques that involve "pick and place", in which each LED has to be individually installed on the microLED backplane.

When you consider that a 4K panel has 8 million pixels, that's a lot of picking and placing, which is time consuming despite being done by a machine. The pick and place process also creates another limitation: pixel density. The individual LEDs can only be located so close to each other when being mounted individually.

A couple of years ago, the smallest 4K microLED display was 110-inch. Samsung has since shrunk microLED panel proportions a bit. But they're still up at 70 inches and over—nowhere near an ergonomic size for a PC monitor. Samsung does produce microLED displays in the 50-inch range, but they are sub-4K resolution and offer poor pixel density. The likes of a 32-inch 4K microLED remains years away.

So there you have it. MicroLED promises so very much. It almost certainly will end up being the next really big thing in display technology and will be the ultimate in flat-panel 2D screens. But sadly it's also several years away from being used in even very high end PC monitors, let alone mainstream and affordable models.



Samsung's microLED tech promises so much, but it's years away from hitting the PC.

standard RGB or red, green blue subpixel structure where each pixel is made of three vertically orientated or striped subpixels in those colors and in that order, left to right. Not so with OLED.

Currently, there are only two players in the OLED panel market: LG and Samsung. Almost every PC OLED monitor on sale, with the exception of some niche displays for professional markets, are based on panels from one of those manufacturers, and neither makes OLED panels with a conventional RGB subpixel structure.

Samsung's OLED panels, as seen in the Alienware 34 AW3423DW and several other 34-inch ultrawide models from brands including MSI and Samsung itself, use a triangular subpixel structure, rather than vertically striped. LG's OLED subpixels, meanwhile, are arranged vertically like a conventional LCD, but in an RWGB arrangement where the "W" is a white subpixel inserted to improve brightness.

For games and video, the precise subpixel structure doesn't matter. However, for computing it does. Windows addresses pixels at the subpixel level to make fonts smoother and crisper, effectively increasing the resolution of a display and allowing for sharper, cleaner fonts. However, this only works on pixels with an RGB subpixel structure. Windows can be set to render to BGR pixels.

However, that only works for the Windows interface and Microsoft's home-grown browser. Many applications, including the Chrome browser, do their one font smoothing and subpixel rendering and cannot be adjusted to work correctly with a BGR subpixel layout or any other non-standard subpixel arrangement.

As a consequence, fonts on OLED monitors suffer from fringing and blurriness compared to conventional RGB LCD panels. This is exacerbated by the fact that the pixel density of current OLED monitors is relatively low. Those 34-inch ultrawide panels are as good as it gets, but they only run at 3,440 by 1,440 pixels, which translates into 110DPI.

Aside from a few megabucks monitors for professional image and video editing, you can't currently get 4K OLED panels in smaller panel sizes like 27-inch and 34-inch. 4k at those screen sizes would have sufficient pixel density to mostly resolve the issues that result from non-standard subpixel structure. However, all non-pro OLED monitors are derived from TV panels, so don't have the pixel density offered by better LCD monitors. It's a double whammy for font rendering in current OLED monitors, then.

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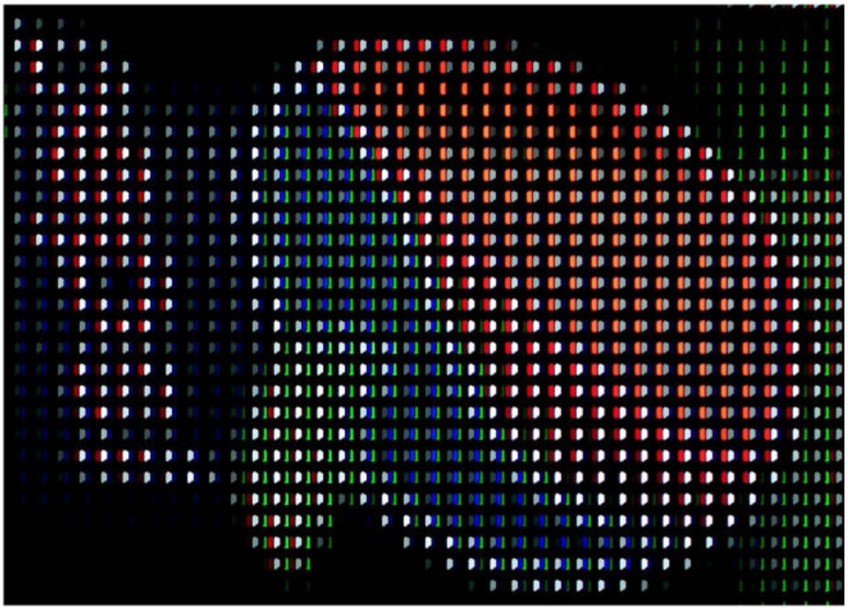
That's particularly frustrating when you consider how expensive OLED monitors are—that Alienware 34-inch panel is over $1,000. Similarly, LG's new OLED PC monitor, the UltraGear 27GR95QE-B, is a 27-inch 2,560 by 1,440 model that lists at $999. That's a lot of cash for a 27-inch 1440p model.

The justification for the lofty pricing, of course, is that perfect per-pixel OLED lighting. But even that isn't all it's cracked up to be. The problem is brightness, or lack of it. The latest OLED monitors from the likes of Alienware, Samsung and LG are quoted as being capable of 1,000 nits or more. Indeed, cutting-edge OLED TVs increase that to over 1,500 nits. Measure them and they can indeed hit those kinds of numbers. But there's a catch. Those numbers are not for full screen brightness, but only a small patch or "window" of perhaps as much as two percent of the visible area.

When measuring what OLED panels are capable of achieving across a large area—or worse, the entire panel—the numbers are far, far lower. The LG UltraGear 27GR95QE-B can't even manage 200 nits full screen, while the Alienware 34 AW3423DW hits around 250 nits. In between those two extremes of a very small area of brightness versus full screen brightness, panel brightness essentially scales. As the ratio of bright to dark screen area increases, the maximum brightness decreases. Exactly how much that matters depends on your use case and what you are viewing.


The subpixel structure on OLED panels, like those of LG, aren't optimized for PC productivity.

OLED can look utterly spectacular in movies and games, especially when the scene or image being shown is a mix of bright and dark areas and when there's a bit more of the latter than the former. But in brighter scenes in games and movies, OLED lacks the punch of even a good conventional LCD monitor with no local dimming, let alone the eye-popping brightness of the most powerful mini-LED monitors.

On the Windows desktop, meanwhile, OLED has its own oddities to rival those of mini-LED. Let's say you have a dark desktop wallpaper, meaning the image being rendered when you boot up is mostly dark. In that scenario, all the little details like icons and menus will really pop. However, if you then open an application like a text document or maybe a browser in a large window that's mostly white, the screen brightness will suddenly drop. Indeed, if you resize the window manually, the brightness of the entire panel will increase and decrease as you make the window smaller and larger. It's awfully clunky, especially when you've paid extra for a supposedly far superior display technology.

For now, there's no satisfactory solution to this. OLED panels are getting incrementally brighter, bit by bit. Measures like heat sinks can allow OLED panels to run a little brighter, and LG has a new MLA micro-lens technology that is likewise said to improve brightness. But none of that stuff as yet has enabled OLED tech to achieve high brightness when a

© PHILIPS, LG

The Philips Evnia 34M2C7600MV is another mini-LED monitor with some pretty obvious image quality issues.

PHILIPS
EVNIA

Would you pay nearly $1,000 for a 27-inch 1440p monitor? That's what LG wants for this OLED panel.

LG UltraGear™ OLED

large proportion of the panel is being lit up. LG's UltraGear 27GR95QE-B has MLA tech, for instance, but can't match Samsung's OLED panels for full screen brightness, let alone LCD monitors, which are several times brighter.

All of this means that while both mini-LED and OLED do bring some major advantages, they're also each very obviously flawed in a PC monitor context. Indeed, we'd argue that for now, a conventional LCD panel probably remains the best compromise overall. That way, you can have proper pixel density and subpixel rendering and a full choice of panel sizes, resolutions and refresh rates, often at much lower prices than the mini-LED and OLED options.

The arguable exception to that and the caveat we mentioned earlier involves mini-LED monitors. Since they are based on the same LCD panels as conventional monitors, you generally have the same broad choice of panel sizes, resolutions, pixel densities, aspect ratios and so on. So whether it's high-DPI and nice crisp fonts or high refresh and lower resolutions for gaming, but with eye-popping brightness, you can have it all with mini-LED.

What's more, the local dimming function can usually be disabled. With this, you can run a mini-LED panel like a conventional monitor with a monolithic backlight while on the Windows desktop and avoid all the distracting issues and problems that come with mini-LED. Then, you can selectively enable local dimming for specific games or video content where it works best.

The catch is the hefty premium you'll pay for mini-LED technology that you might only use occasionally and, of course, the knowledge that you're not getting anywhere near the pixel response of OLED. As for OLED monitors, they definitely have an appeal for gaming. There's no doubting that the incredibly fast response is far superior to any LCD monitor and the limited brightness is only an intermittent annoyance. But with a general purpose monitor for web browsing and productivity usage, the relatively low pixel density and full screen brightness of current OLED monitors are difficult to square with the elevated costs.

For now—and very likely for a few more years to come—as surprising as it is given its many and well-documented shortcomings, LCD remains the better overall compromise for performance computing. It's remarkable, but even here in 2023 there's life yet in that clunky old LCD technology. ⏻

FLAT PANEL PROGNOSTICATION

WHAT'S NEXT FOR PC MONITORS?

If microLED is years away, what's in the immediate future for the PC monitor? In short, refined LCD and OLED displays. But what exactly can you expect? From a productivity perspective, one of the more exciting screens is Dell's UltraSharp U3224KB.

It's a plain old LCD monitor—it doesn't even have a mini-LED backlight. What it does have is 6,144 by 3,456 pixels or full 6K resolution. It's also a 32-inch panel, so that immediately begs comparison with Apple's Pro Display XDR, which is also a 32-inch 4K model. Could the two, in fact, be based on the same LCD panel?

It seems not. The Pro Display has a slightly different 6,016 by 3,384 pixel resolution. Anyway, the Dell screen also sports LG's IPS Black tech for improved contrast, which should clock in around 2,000:1 or about twice as good as typical IPS monitors. It's only HDR 600 certified, so it won't set new standards for brightness. But with 99% coverage of the DCI-P3 gamut, it promises strong color accuracy. And boy is it going to be crispy, with over 220DPI pixel density. Yum.

On the LCD side, we're also looking forward to Samsung's latest Odyssey Neo G9. The last Neo G9 was buggy, but we can't ignore the specs of the upcoming refresh. How about an increase from 49 to 57 inches, 7,680 by 2,160 pixels and 240Hz refresh? Oh, and HDR 1000 certification. More broadly, you can expect zillions of high-refresh 4K monitors in both 27-inch and 32-inch form factors, plus 1440p screens running at 300Hz and more.

One of the more exciting developments for gamers will be the AU Optronics M320QAN03.0. That's actually a bare LCD panel that monitor makers will buy in rather than a finished display. But it promises 4K at 240Hz refresh from a 32-inch IPS form factor. It's due to go into mass production later this year, so we might just see a retail monitor with those specs by the end of 2023.

AU Optronics also has an 8K 32-inch panel with a 4,608-zone mini-LED backlight in the works for this year, which sounds like one heck of a basis for a high-end productivity screen, albeit only running at 60Hz. AU's rival BOE has a similar 5,000-zone 8K 32-inch panel on its roadmap for this year and LG also has a new 8K IPS panel planned, though for now that one is a bit of a mystery regarding further specifications. Still, it's certainly looking like 8K is going to be more widely available by the end of the year. So if you're a high-DPI aficionado, 2023 could just be the year you've been waiting for.

Speaking of 8K, believe it or not, AU Optronics actually has a 32-inch 8K OLED panel on its roadmap. Even better, it's 120Hz capable.

AU Optronics says it will have a conventional RGB subpixel structure, so it's properly optimized for the PC rather than being a TV panel reworked for PC usage. It certainly sounds like it will be the ultimate do-everything display. AU will also offer a 144Hz 4K 32-OLED option, which sounds very appealing, too, but the company hasn't revealed precise availability yet.

In the meantime, we'll see plenty more OLED monitors based on LG and Samsung TV panels. The 27-inch and 34-inch ultrawide models will all be 1440p rather than anything higher resolution, so will be essentially gaming centric rather than high-DPI and thus productivity friendly. And of course, monitors based on full 4K OLED TVs measuring 42 inches and more will become even more common, albeit they're all best suited for gaming, too. The size and pixel density isn't exactly optimal for more general desktop duties.

© DELL

Dell's upcoming 6K monitor slightly beats the Apple Pro Display XDR for pixel count.

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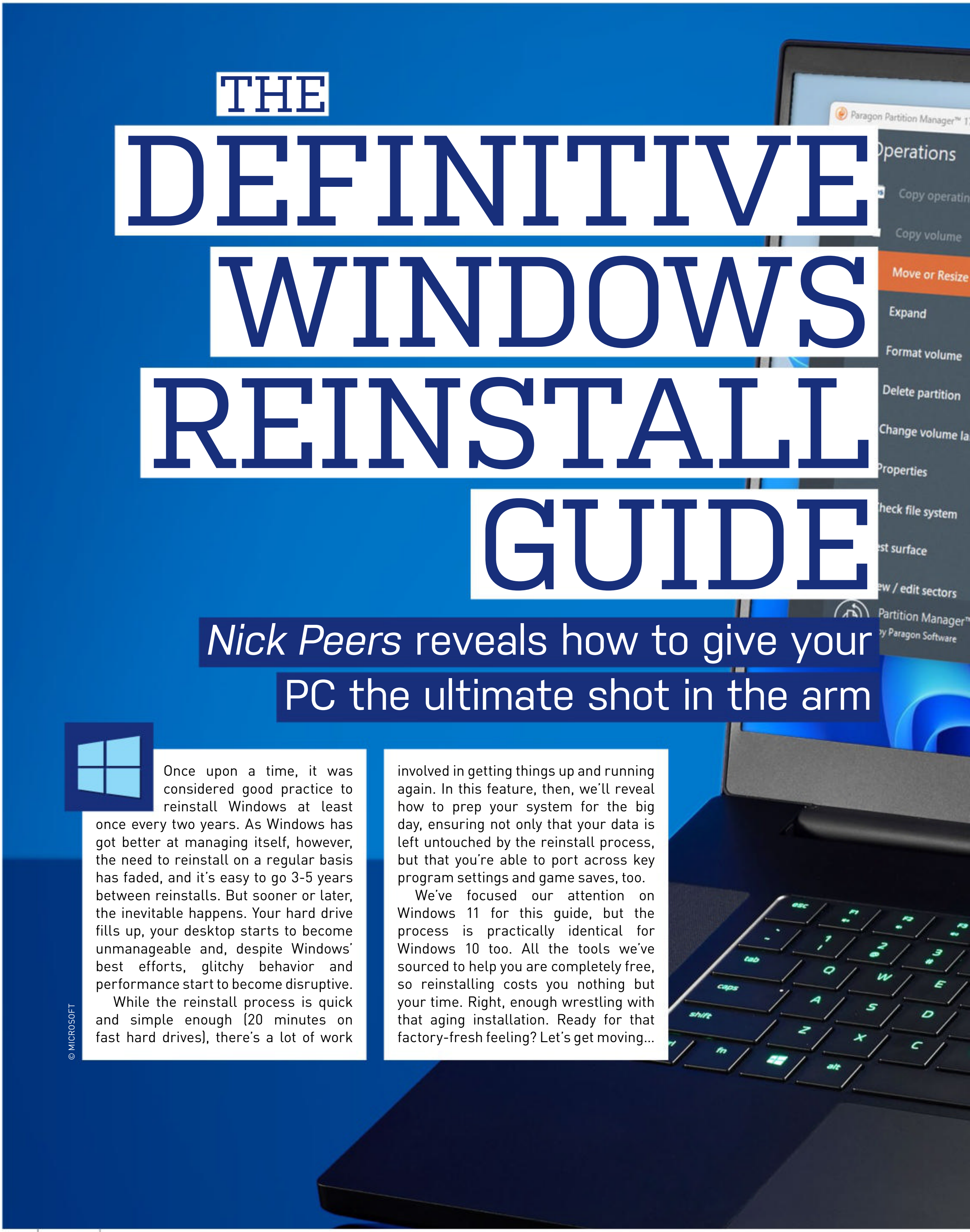
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by Paragon Software

THE DEFINITIVE WINDOWS REINSTALL GUIDE

Nick Peers reveals how to give your PC the ultimate shot in the arm

Once upon a time, it was considered good practice to reinstall Windows at least once every two years. As Windows has got better at managing itself, however, the need to reinstall on a regular basis has faded, and it's easy to go 3-5 years between reinstalls. But sooner or later, the inevitable happens. Your hard drive fills up, your desktop starts to become unmanageable and, despite Windows' best efforts, glitchy behavior and performance start to become disruptive.

While the reinstall process is quick and simple enough (20 minutes on fast hard drives), there's a lot of work involved in getting things up and running again. In this feature, then, we'll reveal how to prep your system for the big day, ensuring not only that your data is left untouched by the reinstall process, but that you're able to port across key program settings and game saves, too.

We've focused our attention on Windows 11 for this guide, but the process is practically identical for Windows 10 too. All the tools we've sourced to help you are completely free, so reinstalling costs you nothing but your time. Right, enough wrestling with that aging installation. Ready for that factory-fresh feeling? Let's get moving...

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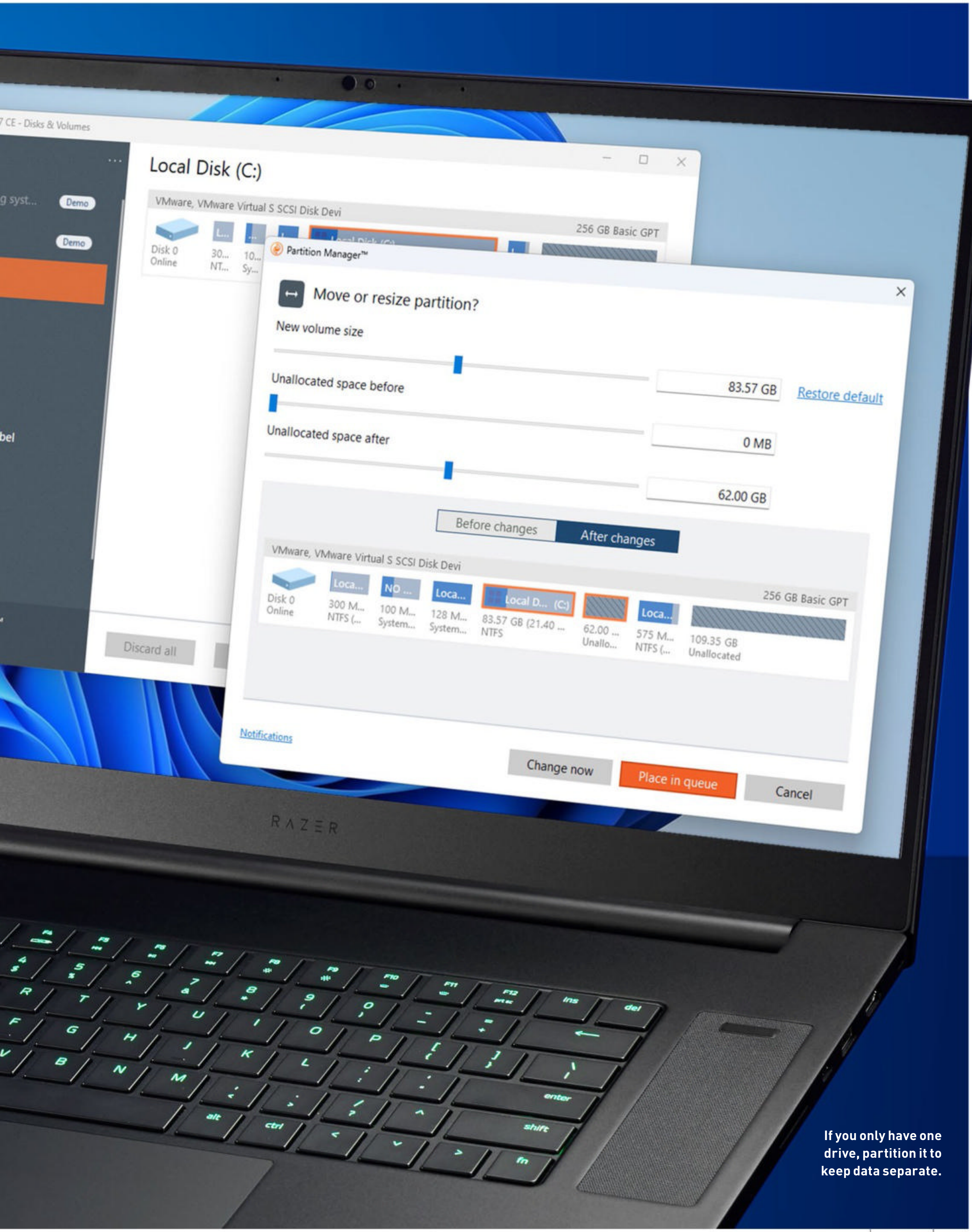

Local Disk (C:)
VMware, VMware Virtual S SCSI Disk Devi
256 GB Basic GPT
Disk 0
Online
Demo
Demo
Partition Manager™
Discard all
RAZER

Move or resize partition?

New volume size: 83.57 GB

Unallocated space before: 0 MB

Unallocated space after: 62.00 GB

Restore default
Before changes
After changes
VMware, VMware Virtual S SCSI Disk Devi
256 GB Basic GPT
Disk 0
Online
Loca... 300 M... NTFS (...
NO ... 100 M... System...
Loca... 128 M... System...
Local D... (C:) 83.57 GB (21.40 ... NTFS
62.00 ... Unallo...
Loca... 575 M... NTFS (...
109.35 GB Unallocated
Notifications
Change now
Place in queue
Cancel

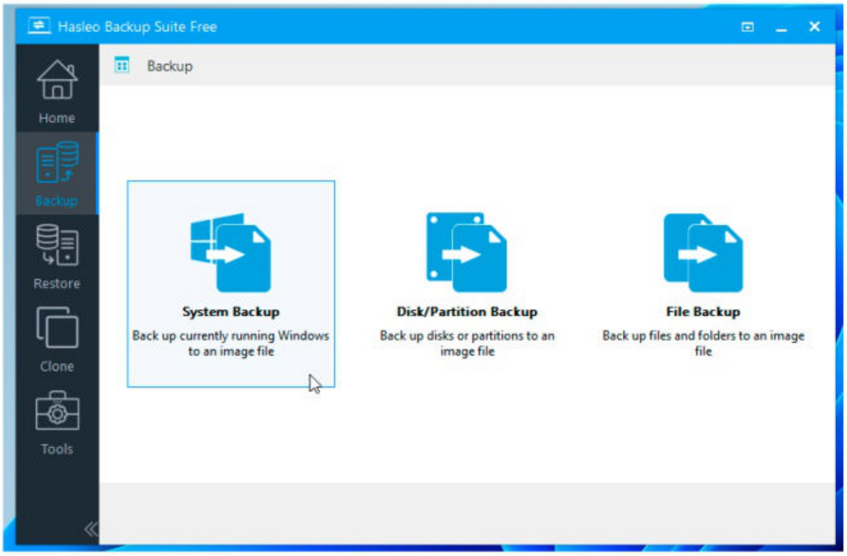
If you only have one drive, partition it to keep data separate.

Before taking another step, you need to make a fail-safe backup of your entire Windows system drive as it currently stands. This ensures that no file or setting gets left behind, and also allows you to roll your system back to its previous state if something goes wrong with the reinstall process, whether that's a mistake during partitioning or you discover that you forgot to back up an important program setting.

You can use your existing drive-imaging tool for this—if you've never used one, now's the time to start: Hasleo Backup Suite (www.easyuefi.com) is our current free tool of choice. If you've been backing up diligently, take one last full backup and verify it before continuing—Hasleo users will find the verify option under Tools, where you should also click the 'Emergency Disk' option to create an emergency USB boot disk or to generate an ISO file for burning to DVD (or adding to your Ventoy USB bootable disk).

AUDIT YOUR PC

With your fail-safe backup and emergency boot disk in place, you can now move on to see what's currently installed on your PC. You can either visit Settings > System > Installed Apps to comb through the list manually, or download Free PC Audit (www.misutilities.com/download.html), a portable tool that produces the same list under its Software tab, but allows you to produce a text file—copy and paste the Software section into its own blank file, then trim the list so that it includes only those programs you plan to bring forward to your new Windows installation.



System Backup
Back up currently running Windows to an image file

Disk/Partition Backup
Back up disks or partitions to an image file

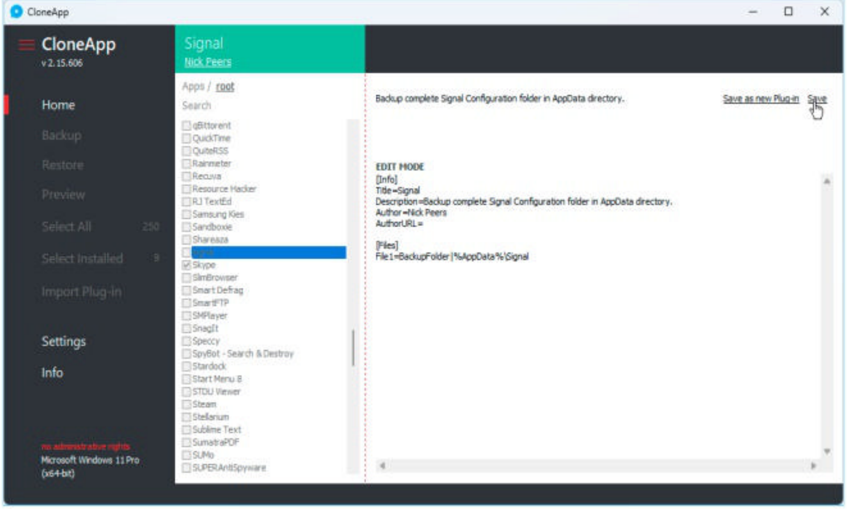
File Backup
Back up files and folders to an image file

Don't reinstall without a fail-safe drive image.

Some software may be difficult to identify—it may be a component of some other application, for example—but the key thing is to list those programs you use regularly and would like to try to preserve your current settings for if possible. Once the list is made, bring together the program installers into a single folder to speed things up post-installation (and identify any that may prove problematic to track down, such as older paid versions of software that is no longer supported). You should also check those that require online activation—you may need to deactivate them prior to reinstalling for a trouble-free reinstall later. Check the program's help or online support if you're not sure.

Also, make a note of any product keys you may need to enter post-reinstall—if you're struggling to track them down, check your email or software packaging, or log into your account to see if the keys are listed there. Also check in case the key's displayed in the program itself (look under About), or try a key finding tool, such as Recover Keys ($29.95, https://recover-keys.com/). This offers a free demo, allowing you to see which apps it has found license keys and other related information (such as activation codes) for. The demo reveals the first four characters of the keys it finds, which may be enough to help you track the rest of the key down without incurring an extra cost—for example, try searching your computer or email messages for those four characters to see if they subsequently show up.

Again, we recommend storing these keys in a text file—or for extra security, how about using your password manager's secure notes feature, which ensures that they're stored safely going forward?



☐ qBittorent
☐ QuickTime
☐ QuiteRSS
☐ Rainmeter
☐ Recuva
☐ Resource Hacker
☐ RJ TextEd
☐ Samsung Kies
☐ Sandboxie
☐ Shareaza
☐ Signal
☑ Skype
☐ SlimBrowser
☐ Smart Defrag
☐ SmartFTP
☐ SMPlayer
☐ SnagIt
☐ Speccy
☐ SpyBot - Search & Destroy
☐ Stardock
☐ Start Menu 8
☐ STDU Viewer
☐ Steam
☐ Stellarium
☐ Sublime Text
☐ SumatraPDF
☐ SUMo
☐ SUPERAntiSpyware

Backup complete Signal Configuration folder in AppData directory.

EDIT MODE

```
[Info]
Title=Signal
Description=Backup complete Signal Configuration folder in AppData directory.
Author=Nick Peers
AuthorURL=

[Files]
File1=BackupFolder|%AppData%\Signal
```

Take an inventory of your apps to decide which ones to keep.

BACK UP PROGRAM SETTINGS

You've spent ages crafting your program preferences to perfection, so save time having to recreate them from scratch by finding ways to back up or at least record those settings before you reinstall. Your final, fail-safe drive image will give you a way back into your old system if you need it, but it's far easier to back these up—whether Registry settings or configuration files scattered across one or more buried folders (or even a combination of both)—and then restore them.

With this in mind, head to https://github.com/builtbybel/CloneApp/releases/ to

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download the free CloneApp tool. Extract the portable app somewhere safe—say, a USB drive or a dedicated data partition that will be left untouched during the Windows reinstall—and then right-click CloneApp.exe and choose 'Run as Administrator' to launch it with administrator privileges.

You'll see that CloneApp supports around 250 programs, but rather than wade through this list by hand, if you click 'Select Installed', it will compare its list to the programs installed on your PC and select them by default, narrowing the number down considerably. From here, just go through the list unchecking any apps that you don't plan to continue using post-reinstall.

Select an item to find out more about it—check it's compatible with your program version, and see where it's backing up data from. Click Edit Plug-in, and you'll see its corresponding plugin is a simple text-based affair that can easily be replicated and amended for other apps not present in the list if you know where to look for the files and/or Registry settings you need to backup.

For now though, go through the list seeing what will be backed up. If you're feeling ultra-cautious, why not manually verify the existence of the folders, files and/or Registry keys being backed up? If anything doesn't match up, it may be that the plugin only works with an older version of the app, and you'll need to investigate another way of backing up your settings (or simply tweaking the plugin—see the box for details).

Towards the bottom of the list, you'll find that CloneApp offers to back up various Windows settings and folders, including all your user folders. As we're going to move your user folders to another drive, you can safely untick all of these, but you may wish to keep other customizations.

Once you're happy with your selection, click Preview to perform a test run and see what'll get backed up, followed by Backup to perform the actual backup. Your backup will be stored in the Backup folder inside the main CloneApp folder—click Settings if for any reason you wanted to save it somewhere else, but for most people this is the sensible place to store your settings.

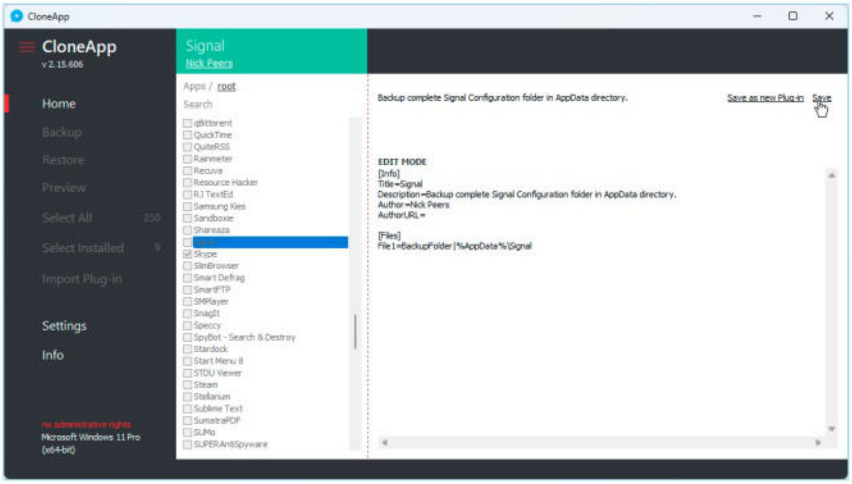
UPDATE & BUILD YOUR OWN CLONEAPP PLUGINS

CloneApp hasn't been updated since late 2020, and while it continues to work well, some of its plugins need updating to work with the latest program versions. For example, the Handbrake plugin only works with pre-1.0 releases of Handbrake because of changes to how the app stores presets.

Fixing this in CloneApp is simple: select Handbrake from the list and click 'Edit Plug-in'. Simply amend presets.xml to presets.json and settings.xml to settings.json, and the program's key preferences and presets (default and user-generated) will be backed up when you next run it. The user_presets.xml line is now defunct and can be safely removed. Click Save when you're done.

These minor edits are all well and good, but what about if you fancy creating your own plugin for a completely unsupported program? Browse to the cloneapp/Plug-ins folder and open #Sample.txt in your text editor. You can then fill out the [Info] section and see that there are three basic elements you can back up: files (BackupFile), folders (BackupFolder) and Registry keys (BackupRegKey). Open the #Rules.txt file from the same folder for an example plug-in with a guide to how to put it all together.

Of course, this all relies on you knowing where your chosen app stores its configuration data. If you're unable to track it down to the usual locations—your personal %AppData% folder, the program's own folder or the HKEY_CURRENT_USER or HKEY_LOCAL_MACHINE\SOFTWARE keys in the Registry—or you're uncertain what Registry entries and files to include, visit the program's support pages or user forums to see if others have followed a similar path, or Google the program and the words 'back up configuration' to see what might be out there. If all else fails, why not email The Doctor to see if he can help?



Backup complete Signal Configuration folder in AppData directory.

EDIT MODE

```
[Info]
Title=Signal
Description=Backup complete Signal Configuration folder in AppData directory.
Author=Nick Peers
AuthorURL=

[Files]
File1=BackupFolder|%AppData%\Signal
```

You can configure CloneApp to back up all your apps.

MORE CONFIG BACKUPS

Next, you need to deal with those programs that aren't covered by CloneApp. First, explore the program's own settings to see if there's an option to back up your preferences—if there is, save it in a sensible location—say 'program backups' folder (inside which you also store CloneApp) on your backup drive, and make a note to restore it from the application after it's been reinstalled. If there isn't, visit the program's support pages or user forums to see if there's a guide you can follow—if it exists, you may even be able to build your own CloneApp plugin off the back of it (again, see the box).

Failing this, try searching in common places where programs are known to store configuration information—the hidden AppData\Roaming folder, for example (press Win + R, type %appdata% and hit Enter to access it). Look for a folder corresponding to the program and examine its contents for clues. Also consider AppData\Local, as well as the program's own entry under Program Files or Program Files (x86).

PARTITION YOUR HARD DRIVE

While Windows' own Disk Management tool can partition, it's not always able to free up all available drive space due to the placement of files at the end of the drive. Instead, you need a third-party tool, and the good news is there are many free tools out there to try. One such tool is Paragon Partition Manager Community Edition (www.paragon-software.com/free/pm-express).

First, work out how to divide up the available drive space—if most of your data resides in your user folders, open File Explorer to C:\Users, right-click your user folder and choose Properties to find out how large it currently is. Look to give your data partition this amount of space, plus a minimum of 20GB, depending on how much drive space is available.

Launch Paragon, creating recovery media when prompted. Once done, select your Windows partition (typically drive C) and click 'Check file system', tick both boxes and click 'Check now', rebooting when prompted. Once back at the desktop, reopen Paragon and select drive C again, except this time choose 'Move or Resize'. Use the 'Unallocated space after' slider to free up enough space for your data partition, then click 'Place in queue'.

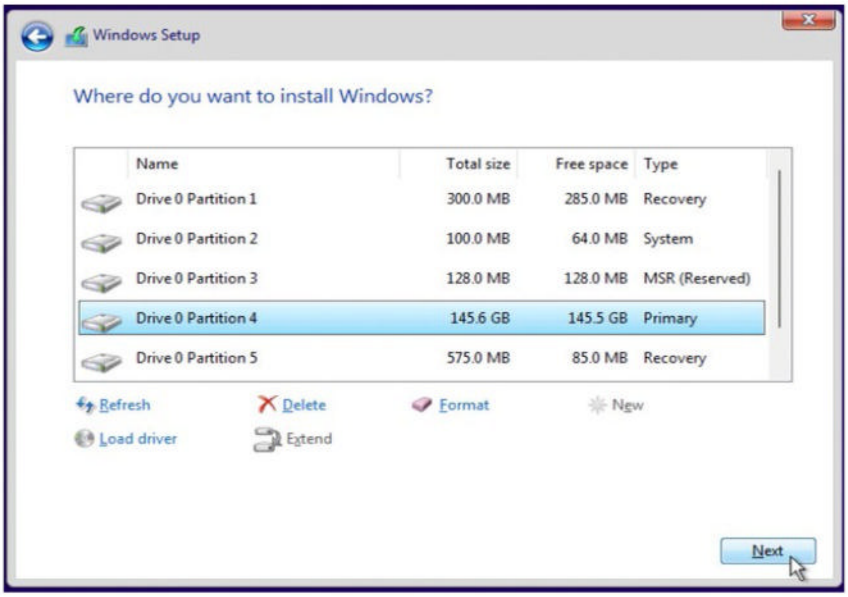
Now, select the unallocated space that appears and choose 'Create volume'. Change the volume label to 'Data' and click 'Place in queue' again. Once done, click 'Apply (2 operations)'. Review your changes and click Apply. A progress box will step you through the process, and once complete your data drive will show up in File Explorer under This PC, ready to receive your user folders.

Note: don't worry if the drive isn't allocated letter 'D' because the letter has already been taken by another drive (your DVD drive for example)—it'll be allocated that letter after Windows has been reinstalled from scratch.

Now is also a good time to vet your list and see if portable versions are available—switching to a portable app means that everything is housed inside a single folder, making it easy to back up and restore. If you do decide to go down this route, use the PortableApps.com launcher as a convenient tool to manage and access these apps.

When it comes to your web browser, CloneApp has you covered, but you can also make use of your online account—simply look for the option to synchronize your settings to upload them to the cloud. Doing so will save you the bother of restoring the backup later—all you'll need to do is log into your account and let it sync everything back.

If all else fails and you're unable to track down any information about program settings, you'll need to make a note of your favorite settings, perhaps with the aid of the built-in Snipping tool to capture each configuration screen and the layout of toolbars and other customizable elements, allowing you to manually restore them later.



Where do you want to install Windows?

Name	Total size	Free space	Type
Drive 0 Partition 1	300.0 MB	285.0 MB	Recovery
Drive 0 Partition 2	100.0 MB	64.0 MB	System
Drive 0 Partition 3	128.0 MB	128.0 MB	MSR (Reserved)
Drive 0 Partition 4	145.6 GB	145.5 GB	Primary
Drive 0 Partition 5	575.0 MB	85.0 MB	Recovery

Make sure you pick the right drive to format.

GAMES

What about backing up your games? The aptly titled Game Save Manager (free, www.gamesave-manager.com) is constantly updating its game-save database to cover more games—nearly 9,800 are currently supported. Like CloneApp, it's run as a portable application, so download it to your backup drive and run it from there. Let it run as an administrator and leave the default settings as they are by clicking OK, followed by Close. It'll then scan your system for supported game saves (as well as related apps like OBS Studio for recording your gameplay) and allow you to back them up—once you've reinstalled Windows and your games, you'll be able to use the tool to restore them.

What about your game preferences? The best place to go for help here is the PC Gaming Wiki (www.pcgamingwiki.com)—search for your game and you should find both 'Configuration files location' and 'Save game data location' sections reveal what files and folders you should look to add to your backup.

HARDWARE DRIVERS

One option with your hardware drivers is to find a suitable tool to back them all up, allowing you to restore them en masse after your reinstall. But a far better—and cleaner—option is to take this opportunity to identify and download any driver packages you need for a fresh install after you've reinstalled Windows.

If you're reinstalling Windows on a laptop or pre-built desktop, all the core drivers you need should either be supplied by Microsoft or made available through your manufacturer's website. You'll also need to download drivers for other core components—your video card, network adapters and sound—plus peripherals like webcams and printers.

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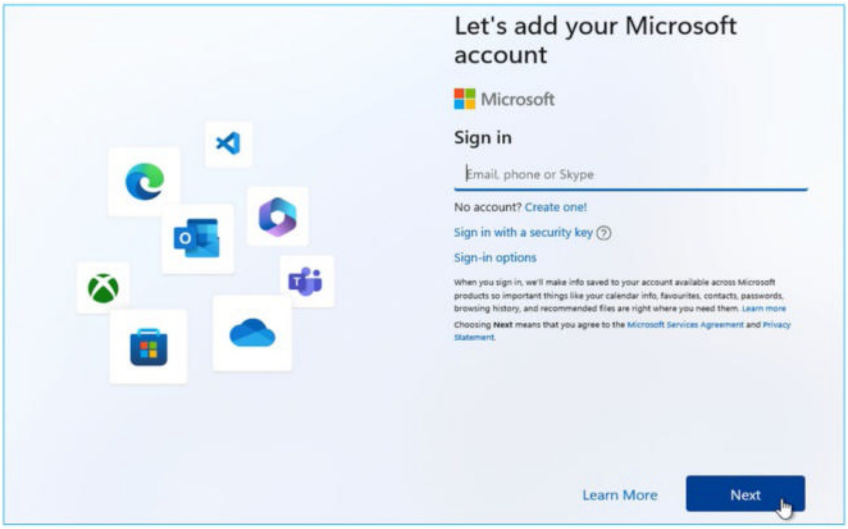
If you need help identifying anything, Free PC Audit lists your hardware by name and manufacturer under System, although no actual driver information is supplied here. Instead, right-click the Start button and choose Device Manager to work through each piece of hardware—focus on the Driver tab, where you'll get driver manufacturer and driver version number. If it's supplied by Microsoft, then this will be installed with Windows 11, and updates will be supplied through Windows Update, but if you want to push the performance envelope, see if the hardware manufacturer supplies its own dedicated drivers.

Create a Drivers folder inside your Windows 11 reinstall folder and store all your downloads here, ready for quick deployment after you reinstall.



Let's add your Microsoft account

Sign in

No account? Create one!

Sign in with a security key

Sign-in options

When you sign in, we'll make info saved to your account available across Microsoft products so important things like your calendar info, favourites, contacts, passwords, browsing history, and recommended files are right where you need them. Learn more

Choosing **Next** means that you agree to the Microsoft Services Agreement and Privacy Statement.

Microsoft
Email, phone or Skype
Learn More
Next

Relink your Microsoft account post-install to activate Windows.

FINAL CHECKS

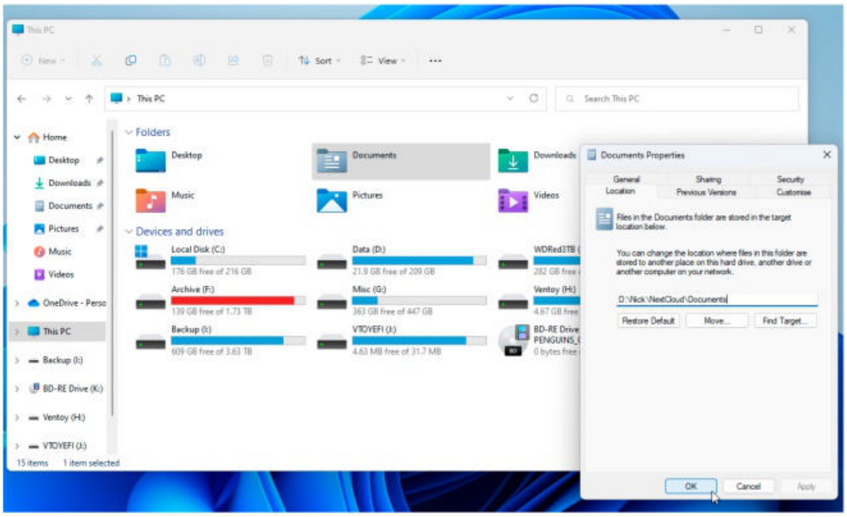
Before taking the plunge, now is the time to separate your data—typically residing in your personal User folders—from your Windows system drive. Ideally, you'll have another drive—say, a fast 512GB or 1TB SATA SSD—lined up for the role (512GB SSDs can be purchased for under $30 these days), but if it's not practical—you have a laptop, for example, and your system drive is at least 512GB in size, then you can always partition it in two following the advice in the box.

Next, it's time to move your user folders to the new drive. Rather than do this using simple drag and drop, open File Explorer and navigate to your Home directory. Right-click the Documents folder under Quick Access and choose the Properties > Location tab. Click Move... to choose a suitable location on your data drive or partition (say, D:\<Your Name>\Documents) and click Apply. When prompted to move your existing data across, choose Yes. Now repeat for all your other user folders: Pictures, Music, Videos, Desktop and Downloads.

Note: moving your data to another drive protects it from data loss should something happen to your Windows installation going forward, but the data itself remains vulnerable—use Hasleo's file backup tool to create a regular back up of these folders to your backup drive, too.

Next, dig out a USB flash drive—at least 8GB in size—and download the latest version of the Media Creation Tool for Windows 10 (https://go.microsoft.com/fwlink/?LinkId=691209) or Windows 11 Installation Assistant (https://go.microsoft.com/fwlink/?linkid=2171764) and use it to create bootable installation media. If you want to reinstall from DVD, visit www.microsoft.com/software-download/windows11 to download the ISO file, which can also be used in conjunction with a Ventoy USB disk (just copy the ISO file across).

You've backed up your application settings, downloaded hardware drivers and program installers, made a note of product keys (and deactivated software that requires reactivation), ensured your data is moved to a different drive to Windows itself, created Windows installation media and taken one final drive image of your entire system drive—just in case (if you've not already verified it, do so now). Take a deep breath—it's time to reinstall.



Documents Properties

Files in the Documents folder are stored in the target location below.

You can change the location where files in this folder are stored to another place on this hard drive, another drive or another computer on your network.

D:\Nick\NextCloud\Documents

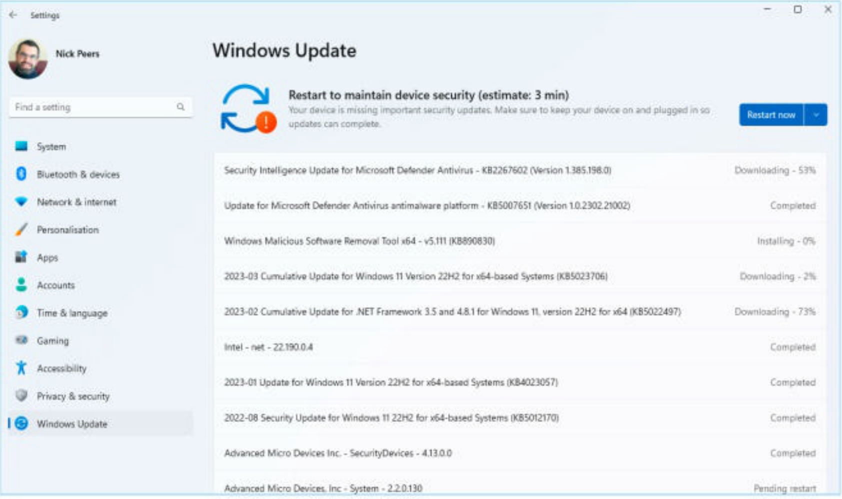
This PC
New
Sort
View
This PC
Search This PC
Home
Desktop
Downloads
Documents
Pictures
Music
Videos
OneDrive - Perso
This PC
Backup (I:)
BD-RE Drive (K:)
Ventoy (H:)
VTOYEFI (J:)
15 items 1 item selected
Folders
Desktop
Documents
Downloads
Music
Pictures
Videos
Devices and drives
Local Disk (C:)
176 GB free of 216 GB
Data (D:)
21.8 GB free of 209 GB
WDRed3TB
282 GB free
Archive (F:)
139 GB free of 1.73 TB
Misc (G:)
363 GB free of 447 GB
Ventoy (H:)
4.67 GB free
Backup (I:)
609 GB free of 3.63 TB
VTOYEFI (J:)
4.63 MB free of 31.7 MB
BD-RE Drive
PENGUINS_
0 bytes free
General
Sharing
Security
Location
Previous Versions
Customise
Restore Default
Move...
Find Target...
OK
Cancel
Apply

Don't forget to link Windows back to your user folders.

REINSTALL WINDOWS

Although the following steps are written for the latest version of Windows 11 (22H2 release), they should work with minimal changes in Windows 10, too. First, insert your boot media, then open Settings and navigate to System > Recovery and click 'Restart now' next to 'Advanced startup'. After rebooting to the Windows boot menu, select 'Use a device' followed by your boot media. If prompted, press any key to boot from CD or DVD.

The Windows setup process is straightforward—start by verifying your language, currency and keyboard formats and click Next followed by 'Install Now'. You'll be prompted to enter a product key—assuming you have a digital license,



Windows Update

Restart to maintain device security (estimate: 3 min)

Your device is missing important security updates. Make sure to keep your device on and plugged in so updates can complete.

Security Intelligence Update for Microsoft Defender Antivirus - KB2267602 (Version 1.385.198.0) Downloading - 53%
Update for Microsoft Defender Antivirus antimalware platform - KB5007651 (Version 1.0.2302.21002) Completed
Windows Malicious Software Removal Tool x64 - v5.111 (KB890830) Installing - 0%
2023-03 Cumulative Update for Windows 11 Version 22H2 for x64-based Systems (KB5023706) Downloading - 2%
2023-02 Cumulative Update for .NET Framework 3.5 and 4.8.1 for Windows 11, version 22H2 for x64 (KB5022497) Downloading - 73%
Intel - net - 22.190.0.4 Completed
2023-01 Update for Windows 11 Version 22H2 for x64-based Systems (KB4023057) Completed
2022-08 Security Update for Windows 11 22H2 for x64-based Systems (KB5012170) Completed
Advanced Micro Devices Inc. - SecurityDevices - 4.13.0.0 Completed
Advanced Micro Devices, Inc - System - 2.2.0.130 Pending restart

The first Windows update after a reinstall is a big one.

simply click ‘I don’t have a product key’ to skip this step. Next, you’ll need to select your Windows 11 edition—typically Home or Pro.

Agree to the license terms, then choose the Customized version to install a fresh copy of Windows from scratch. The next step is the trickiest of the entire reinstall process—you need to identify your Windows system partition, which could be complicated if you have multiple internal drives fitted. Use the ‘Total size’ and ‘Free space’ indicators to identify it, but if in any doubt, cancel the process, boot back into Windows to identify the correct drive before returning to this step.

The reason why it’s critical to identify the right drive is apparent the moment you select it and choose Format to wipe it clean. Make a note of the warning, then click OK. Once the format is complete, click Next. Now it’s just a case of sitting back and waiting for Windows to install itself—a remarkably quick process these days, particularly on NVMe drives.

SET UP WINDOWS 11 AFRESH

If you’ve not reinstalled Windows for a while, the post-install process is, shall we say, different, even compared to Windows 10. After your first reboot, you’ll be asked to confirm your country and keyboard layout method, then click Skip unless you want to add a second keyboard. Finally, wait for Windows to prompt you to name your PC (for identifying over the network) to complete the first part of the post-setup.

After another reboot, you’ll be prompted to sign into your Microsoft account, which will handle the reactivation process quietly behind the scenes, as well as giving you access to select settings synced from your previous installation, such as your choice of desktop wallpaper. If you’ve not disabled OneDrive, you should be given an option to sync certain Windows settings as well as OneDrive files and apps you’ve installed through the Store. Make a careful note of the PC name and sync date—if you have multiple Windows devices or don’t want to bring over your previously installed apps, click ‘View more options’ to choose ‘Set up as new device’ or select a different backup.

You’ll next be prompted to simplify the login process—if Windows detects a suitable device (webcam or fingerprint reader), you’ll be invited to set that up, otherwise you’ll be given the option of choosing a PIN.

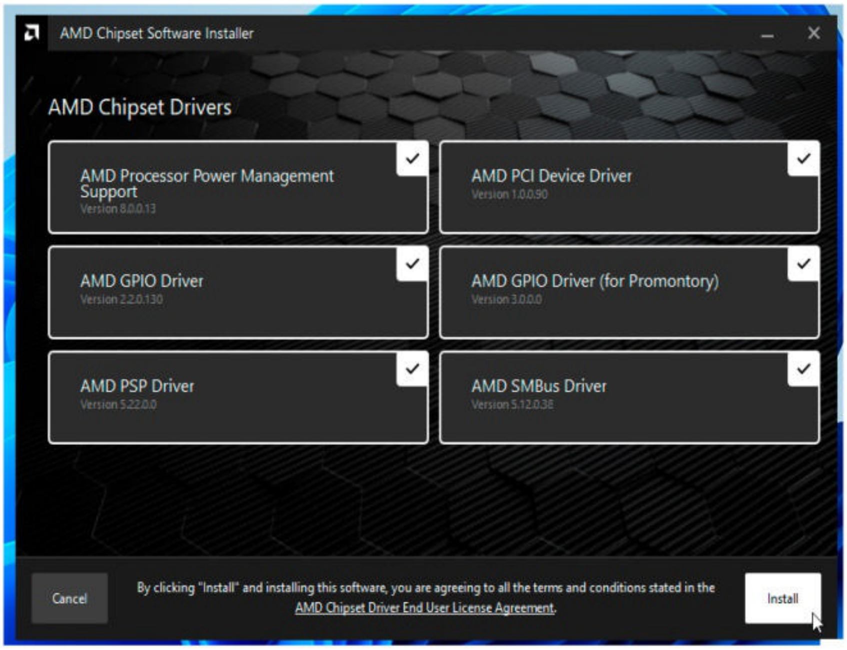
The next few steps require you to pause for a moment—Microsoft is going to bombard you with options designed to loosen your privacy settings—some, like location settings, are more useful than others, like setting an advertising ID to make it easier for advertisers to track you. There’s also a whole section on Microsoft ‘experiences’, involving personalized tips, recommendations and—you guessed it—ads. Thankfully, you can skip this and set up a connection between your Android phone and your PC if you wish.

Next, you’ll be invited to link your Desktop, Documents and Pictures folders to OneDrive, so they’re constantly being backed up—if this doesn’t fit in with your workflow, simply click ‘Only save files to this PC’ (but note OneDrive will still be installed and running after reinstall completes). Microsoft will then attempt to get you to sign up to its PC Game Pass—again ‘Skip for now’ is available.

That’s job (finally) done—Microsoft will then spend a few minutes tuning your system and getting it set up, then you’ll find yourself with a very clean and uncluttered desktop.

GET SET UP (AGAIN)

Now the task of putting everything back to together begins. Start by mapping your user folders to their new home: open File Explorer, right-click



AMD Chipset Drivers

☑ AMD Processor Power Management Support
Version 8.0.0.13

☑ AMD PCI Device Driver
Version 1.0.0.90

☑ AMD GPIO Driver
Version 2.2.0.130

☑ AMD GPIO Driver (for Promontory)
Version 3.0.0.0

☑ AMD PSP Driver
Version 5.22.0.0

☑ AMD SMBus Driver
Version 5.12.0.38

By clicking "Install" and installing this software, you are agreeing to all the terms and conditions stated in the AMD Chipset Driver End User License Agreement.

Reinstall key system drivers for maximum performance.

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your Documents folder and choose Properties > Location tab, then repeat the steps you did prior to reinstalling Windows to link each folder to the drive where you moved them.

Next, reinstall your drive imaging tool to take your first post-reinstall backup. This means that if anything goes wrong with your restoration, you can simply roll back and start again from here instead of having to go through the whole reinstall process again. Don't forget to verify your backup before proceeding further.

Next, take a trip to Windows Update and bring your PC bang up to date—you may need to run it a couple of times (with at least one reboot) before everything is in place, and don't forget to check under 'Advanced Options > Optional Updates' to see if any additional drivers are waiting.

Speaking of drivers, once your PC is up to date, go to Device Manager—you'll see that while most (if not all) your hardware has been recognized, the drivers are all quite old, including your graphics card. So now's the time to install all those drivers you collected earlier to ensure your PC is running as fast as it can.

RESTORE YOUR APPS

Here's a good time to take another drive image—if you are running Hasleo Backup Suite Free, click Actions next to your current backup and choose Backup > Incremental to minimize the new backup size (and time—it'll complete in just a few minutes). Again, don't forget to verify it before proceeding.

Now begins the task of restoring your apps and their settings. Start with the essentials: your security software, office suite, and other tools you find yourself using on a daily basis. After installation, let them run at least once to create the required folders, then look to restore your backed up settings—either through the app itself, or by manually copying files back to their original locations.

If you backed up using CloneApp, you can either relaunch the app and choose Restore, which should ask you to confirm the backup by date before you click Yes. Note that this will restore all settings you previously backed up, so it's worth leaving until all the relevant apps have been reinstalled (or you can manually browse the backup folder and restore files and Registry entries separately). Also, don't forget to restore any saved games using Game Save Manager.

Congratulations—Windows has been reinstalled and your system is up, running and much faster than it was before. Over the next few weeks you'll find yourself restoring other apps and settings as you need them, but the main job is done. All that's left to do is set up two scheduled backup jobs in Hasleo—one system to cover your Windows partition, and either a partition- or file-based backup to cover your data drive—and you're good to go. Until the next reinstall... ⏻

RESTORE FILES AND SETTINGS FROM YOUR FAIL-SAFE BACKUP

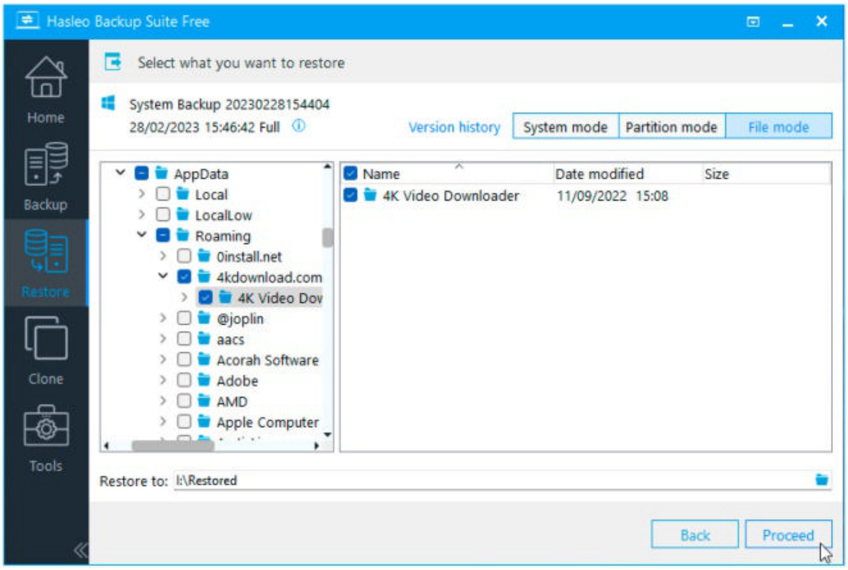
It doesn't matter how diligent you are prior to reinstalling Windows, there's always a file, app or setting that slips through the net. That's where your fail-safe drive image earns its corn, as nothing is truly lost. First, you need to mount the image as a virtual drive in Windows—the process varies according to the drive image tool you use, but Hasleo users should open the app and select Restore, then choose 'Browse image to restore'. Select your fail-safe drive image—when the partitions appear, choose 'File mode', which allows you to browse the image by drive letter and folder to locate the folder or files you want to restore. Choose where to restore the data to (we recommend copying them first to a neutral spot—say a 'Restored' folder—before moving them back to their original location) and click Proceed.

Restoring Registry entries is a little trickier—first, you need to obtain the old Registry files (or 'hives') from your backup. You'll find them in the following locations:

- HKEY_LOCAL_MACHINE \SAM—Windows\system32\config\SAM
- HKEY_LOCAL_MACHINE \SYSTEM - Windows\system32\config\SYSTEM
- HKEY_LOCAL_MACHINE \SOFTWARE - Windows\system32\config\SOFTWARE
- HKEY_USERS \.Default - Windows\system32\config\DEFAULT
- HKEY_CURRENT_USER - Users\<Username>\ntuser.dat

Extract them all to your Restored folder, then open Registry Editor (press Win + R, type regedit and hit Enter), and select HKEY_LOCAL_MACHINE from the list. Select File > Load Hive. You can then browse to your Restored folder and load the Registry hive you need (typically HKEY_CURRENT_USER or HKEY_LOCAL MACHINE\SOFTWARE.

Browse these keys for the missing settings, export them to your hard drive as .REG files and then double-click each file in turn to reimport it back into the Registry.



Select what you want to restore

System Backup 20230228154404
28/02/2023 15:46:42 Full

Name	Date modified	Size
☑ 4K Video Downloader	11/09/2022 15:08	

Restore to: I:\Restored

Access any file or Registry setting from your old installation.

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VIDEO ENCODI

How to use the latest GPUs to boost your livestreaming video quality

by Jarred Walton

NG SHOWDOWN

© OLLY CURTIS/ACTIVISION

THE ERA OF PHYSICAL MEDIA is largely dead and buried. Though many people still have old VCR tapes, stacks of DVDs, and the more modern Blu-ray discs at home, mention optical discs and the rising generation won't know what you're talking about.

We've long since stopped including recommendations for optical drives in our PC builds, though it's still possible to buy a Blu-ray drive for a PC—just like it's possible to ignore the smart features and connectivity options most TVs now include, and instead opt for a 30-second delay while the Blu-ray player loads up a menu screen. Our quest for instant gratification via Netflix, YouTube, Twitch, or any number of other streaming services means that people are more comfortable using Roku than a DVD.

The consumption of streaming videos dwarfs the production of content, but it's in the creation stage that quality levels are defined. H.264 remains the most popular video codec of the past decade but as we cram higher resolution and higher quality content into the same bandwidth, its reign may be coming to an end. The good news is that its replacement could already be here.

THE NEED FOR COMPRESSION

THE PRIMARY REASON for any video codec—coder/decoder—is to enable the transmission of content without requiring lots of bandwidth. Take a standard movie with a 1080p resolution, running at 24fps: 1920 × 1080 × 24 (fps) × 3 (bytes per pixel) × 8 (bits per byte) = 1,194,393,600 bits of data for every second of uncompressed video. People with faster than gigabit connections might be able to handle that sort of data stream, but it's inefficient.

But 1.2Gbps of data is only for 24fps content. A graphics card running at 1080p and 60Hz sends 3Gbps of data to the display. Modern high refresh rate displays can transmit at up to 54Gbps in the case of AMD's DisplayPort 2.1 connection—4K at 240Hz for instance needs about 48Gbps. But sending gigabits of data over an HDMI or DisplayPort connection is one thing; sending it over the internet or storing content on a hard drive or SSD is another.

Using a video codec is like using JPG or PNG compression for images, rather than uncompressed bitmaps, but with video, there's a third dimension available. Where a high-quality JPG file might be able to reach compression ratios of 12:1, video codecs can take uncompressed video and deliver good-quality alternatives with compression ratios of 250:1, 500:1, and even 1000:1 or more. And it's a good thing because it's what makes video streaming practical.

The Sony Large screen 65in rear projection TV was released at $3,000 in 2004.

When you watch a 4K 60fps YouTube video, your PC sends around 12Gbps of data to your monitor. Your internet connection probably only has to deal with about 20Mbps. But not all video codecs are created equal, with differences in the algorithm, hardware requirements, and licensing costs. We've covered the three major contenders below.

THE THREE MAJOR VIDEO CODECS

H.264
THE MARKET LEADER

Before H.264 (also called AVC or Advanced Video Coding), there were other standards like MPEG2 and MPEG (Motion Picture Experts Group), with the former used for DVDs. But with the shift to high-definition content in the early 2000s, we needed something better. A consortium came up with new standards to enable higher resolution, higher quality content without bloating the bandwidth or bitrate requirements—H.264 was the result.

The initial release in 2003 consisted of three profiles: Baseline, Main, and Extended. In 2005, the High profile was added with several variations and, in 2007, a major update added Scalable Video Coding (SVC), which helped kickstart streaming video. With SVC, it was possible to scale down the bitrate of a video, while also reducing the quality, to stay within bandwidth requirements. If you watched a video stream that suddenly becomes blocky and pixelated, that was SVC at work. The only other major change was support for Multivideo Video Coding (MVC), which was necessary for content intended for stereoscopic displays.

A key factor in the popularity of H.264 was that the MPEG Licensing Association (MPEG LA) allowed the free use of H.264 technologies for video streaming to end users. It remains the standard, though the bitrates required for higher quality are starting to become rather bloated.

HEVC/H.265
A POORLY RECEIVED SEQUEL

H.264 was designed to work with relatively low-power hardware, especially for decoding purposes. What was once considered a demanding algorithm would become child's play for modern hardware, and with excess computational power available, work was put into the next standard: H.265 or HEVC, High-Efficiency Video Coding.

First published in 2013, it built on the foundations of H.264, but with newer features designed to improve the achievable compression ratios. The first consumer graphics cards to support HEVC encoding were Nvidia's GTX 900-series back in 2014. Over the next several years, support for HEVC continued to improve, but it never saw the widespread adoption of H.264. That's largely thanks to more stringent enforcement of royalties for the standard, so while just about every modern laptop, PC, and smartphone supports HEVC, a lot of streaming internet content has opted to stick with H.264 or look for other options.

Ignoring uptake and popularity, HEVC delivers on the promise of higher video quality with lower bitrate requirements. It's not a huge difference at 1080p, where a good quality HEVC video can do with 6Mbps what H.264 might need 8Mbps to manage. But move up to 4K video content and HEVC can potentially cut the bitrate in half relative to H.264.

AV1
THE ROYALTY FREE ALTERNATIVE

Because of the royalties associated with HEVC, some of the largest technology companies—Amazon, Apple, AMD, ARM, Google, Intel, Microsoft, Netflix, and Nvidia—formed the Alliance for Open Media, which created an HEVC rival called AV1 in 2018. There was also VP9, a predecessor to AV1, created by Google and used by YouTube, but while decoding support for VP9 has been around for some time, hardware-accelerated encoding support has been lacking. Ultimately, AV1 aims to do what neither HEVC nor VP9 could and offer a quality, royalty-free codec.

Despite being published as AV1 version 1.0.0 with Errata 1 in mid-2019, with a reference software-based encoder and decoder, AV1 adoption didn't immediately take off. In fact, it's only in the past year or two that talk of AV1 decoding and encoding support started to become important. Existing graphics cards on the PC for example have used a hybrid software plus hardware decoding approach for AV1 video, which is fine for high-end hardware but can be a bit too demanding on low-power laptops. That all changed with Intel Arc, Nvidia Ada, and AMD RDNA 3, which provide full decoding and encoding support for AV1.

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HARDWARE ACCELERATED ENCODING

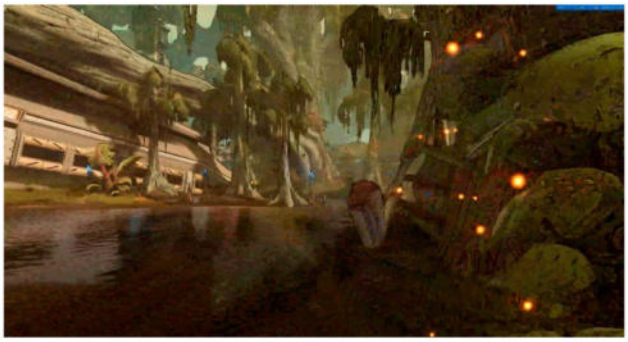
IF YOU'RE LOOKING FOR ABSOLUTE maximum quality for archiving videos that you might want to look back on decades in the future, nothing beats higher bitrates. Storage is relatively cheap these days, with hard drives now starting at around 1.5 cents per GB. What does that mean in practical terms? You can store excellent quality videos for less than 15 cents per hour of content. Depending on your codec of choice, you could even cut the cost requirements in half without sacrificing much in the way of quality.

There's also the tradeoff of encoding time versus quality, so if you want to minimize file size and are willing to spend more processing time, you can do that. There are limits to how far this can take you, however. Even with the best current video codecs, if you try to squeeze 4K content into 2Mbp, you won't get a great result, you'd be better off targeting a lower resolution with the same bitrate. There's still the matter of how to best use that bitrate, and that's where software encoders can excel, doing two passes with the first focused on figuring out which areas of each frame benefit most from more bitrate, and which areas need less.

The problem with software encoding is that it can be slow, especially on older processors. The Ryzen 9 7950X and Core i9-13900K can generally handle 4K encoding in real-time at more than 60fps, but they use a lot of their number-crunching power on the task. Playing a demanding game while dedicating half of your CPU cores to video encoding can result in stutters and other undesirable behavior. There's also the matter of H.264 encoding being quite complex back when it was first introduced.

The solution is hardware-accelerated video encoding, which has been around since 2011. Nvidia Kepler GPUs added NVENC (Nvidia Encoder) for H.264 with the GTX 600-series in 2012. AMD added video encoding support with its HD 7000 line of cards, via its VCE (Video Code Engine). Intel's integrated graphics solutions have also included video encoding support via QuickSync Video (QSV) with the first Sand Bridge (2nd Gen Core) processors.

The benefit of these video encoders is that they offload most of the complex work to dedicated hardware, leaving your CPU and most of your GPU free to do other work. The drawback is that they're generally not as flexible as software encoders, but for real-time encoding, they can be a great solution. This brings us to the heart of the matter—how good are the AMD, Intel, and Nvidia encoders, with H.264, HEVC, and now AV1? We tested multiple generations of hardware, but the focus here will be on the latest solutions that have all added AV1 support.



***Borderlands 3* streaming at 4K via H.264 with just 2Mbps? Sure, it's technically possible, if you don't mind the blocky mess that results.**

TESTING OLDER GENERATION GPUS

If you're not worried about AV1 encoding support, chances are that your current GPU supports H.264 and HEVC encoding. The good news is that HEVC encoding performance and quality haven't changed much over the years. We ran additional tests with older generations of GPU hardware (tinyurl.com/video-codecs) and also additional encoding tests using other videos.

AMD's results remain at the bottom of the charts in terms of quality, and performance was also slower in the pre-RDNA generations of hardware. Nvidia's performance and quality have only improved a small amount over the years, but that's likely due in part to already being excellent. One interesting aside is that HEVC encoding performance took a step back in some cases, with Nvidia's Turing and Ampere being slightly slower than Pascal. That's likely because, by 2018, HEVC clearly wasn't winning the codec wars. But the latest Ada Lovelace, Arc, and RDNA 3 GPUs are faster than their predecessors.

Do you need to upgrade your graphics card for video encoding purposes? If you're livestreaming your gaming sessions on a regular basis, and you want to switch to AV1, it might be worth considering.

But, in general, the Nvidia GPUs going as far back as Pascal continue to do just fine. And if you're only watching videos and aren't creating your own streams, just stick with whatever you're currently running for as long as you can.

Nearly every GPU made in the past decade has video encoding hardware for H.264 and HEVC, though speed and quality might be lower. (From left to right): AMD Radeon R9 390, Radeon RX 590, GeForce GTX 1650 4GB, AMD RX Vega 64.

VIDEO ENCODING QUALITY AND PERFORMANCE COMPARED

		CPU 13900K		AMD RX 7900 XTX		Intel Arc A770		Nvidia RTX 4090	
	Codec / Bitrate	FPS	VMAF	FPS	VMAF	FPS	VMAF	FPS	VMAF
1080P	H.264/3M	279	58.76	429	47.29	391	63.16	489	63.62
	H.264/6M	264	81.07	427	71.91	395	81.06	491	82.54
	H.264/8M	251	87.28	426	79.64	393	86.70	494	88.21
	H.265/3M	106	70.30	418	66.23	434	74.67	466	73.35
	H.265/6M	88	84.73	415	81.58	435	88.09	466	86.71
	H.265/8M	81	89.20	414	86.60	434	92.10	469	90.79
	AV1/3M	257	75.32	493	67.97	448	71.78	493	75.19
	AV1/6M	205	86.30	497	82.74	438	85.39	494	88.35
	AV1/8M	212	89.65	496	87.51	440	89.70	493	92.22
4K	H.264/8M	84	47.69	163	44.31	103	64.63	134	57.22
	H.264/12M	81	65.08	163	57.55	105	72.54	133	71.48
	H.264/16M	78	75.68	162	69.37	105	80.01	133	79.77
	H.265/8M	36	70.57	163	67.33	126	75.00	133	73.29
	H.265/12M	34	79.99	163	77.23	127	83.40	133	82.53
	H.265/16M	33	85.40	162	83.54	127	88.44	133	87.35
	AV1/8M	98	73.50	200	70.76	121	73.03	126	76.14
	AV1/12M	90	80.71	198	80.05	119	81.59	127	84.85
	AV1/16M	78	84.86	198	85.74	118	86.61	127	89.46

All testing was done on a Core i9-13900K PC with 32GB of DDR5 memory, using reference model graphics cards from AMD, Intel, and Nvidia.

THE RESULTS OF OUR ENCODING TESTS are pretty interesting, especially when we look back at older GPUs (see sidebar). Even though H.264 remains the most popular codec, the loss in quality at lower bitrates is quite significant. Regardless of which encoder you're looking at, HEVC and AV1 can do better quality with 6Mbps at 1080p than H.264 can manage with 8Mbps. At 4K, the quality gap increases, with HEVC and AV1 8Mbps quality often surpassing H.264's 16Mbps result.

The problem is that video streaming services until recently have generally only supported H.264 since it was free. Discord and other tools are adding AV1 support now, thanks to GPU support from the major companies plus the lack of licensing fees. The only difficulty is that you'll need either a powerful CPU or an expensive latest-generation graphics card to get AV1 encoding support… unless you opt for an Intel Arc GPU.

While we're only showing results from the fastest GPU from each vendor, the video encoding is handled by a fixed function block and is the same on all of the other GPUs. Intel's Arc A380 had identical quality results to the A770, and performance was effectively the same as well—the A380 was actually seven percent faster, thanks to a factory overclock on the card we used for testing. Nvidia's RTX 4070 Ti was, likewise, identical in performance and quality to the 4090, and the same goes for AMD's RX 7000-series.

Comparing the four solutions, counting CPU encoding, there are also some telling results. AMD's encoder placed last in quality for nearly every single test we ran. The one exception was AV1 16Mbps, where it just edged past the CPU encoding (done with libsvtav1). But again, CPU encoding tends to be far more flexible, so if we could accept slower speed we could also boost the quality. At the other end of the scale, Nvidia's latest NVENC hardware took first place for quality with H.264 at 1080p and AV1 at both 1080p and 4K, while Intel's Arc had the best quality at 4K with H.264, as well as winning with HEVC at both 1080p and 4K.

The other side of the coin is performance, but it tends to be less of a factor once you get past 60fps. Maybe in the coming years 4K 120fps streaming will become more widely supported, though if that happens, Intel and Nvidia might need to opt for slightly lower quality to boost performance. Otherwise, all three GPUs easily break into the triple digits, with AMD's AV1 performance topping the 4K charts if you prefer speed over quality.

The CPU results are also interesting. H.264 quality can be improved at the cost of FPS, but the AV1 results make that almost a non-issue. Rather than getting slightly higher quality at much lower encode rates with H.264, AV1 at 4K still managed to break 60fps on the 13900K. HEVC using the libx265 library is another story, with performance barely breaking 30fps—one more reason it probably didn't catch on as much as its predecessor.

ONE CODEC TO RULE THEM ALL?

GIVEN THE UBIQUITY OF H.264, it's a safe bet that it's not going away any time soon. Smartphones, PCs, and laptops have all had good H.264 decoding support for a decade, and while newer codecs can improve video quality, companies aren't in a huge rush to change their existing infrastructures. H.264 works, even if the quality for a given bitrate isn't as good as what you get with newer codecs like HEVC and AV1. But there was a time when H.264 was still trying to gain traction, and it took at least five years from its inception until support really started to take off.

AV1 has the backing of some major names, and if it can avoid legal pitfalls and remain free to use, it's the best current bet as the successor to H.264. Quality isn't a huge jump from HEVC, but it doesn't need to be. Once we start seeing lower-tier RTX 40-series graphics cards—and the RTX 4050 and 4060 are already shipping in laptops—plus AMD's RX 7000 cards, more people could start to use it, and streamers in particular should appreciate the quality improvements that it affords at lower bitrates. But even while we're just getting started with AV1 adoption, the video standards companies are already looking forward to what comes next. H.266 / VVC (Versatile Video Coding) hasn't seen much support so far, even though the final standard was approved in 2020.

Laptops have all had good H.264 decoding support for a decade.

Maybe that will change. But with 8K TVs starting to come down in price, it's a safe bet that we'll continue to see plenty of advances in the realm of video codecs.

HOW TO MEASURE VMAF

Our quality and performance results are all generated via the open-source tool ffmpeg. You can download this tool for free and it supports all of the latest GPUs with the current nightly builds—the latest official 5.1.2 release is from September 2022 and only has AV1 support for Intel's Arc GPUs right now. ffmpeg supports VMAF, Netflix's Video Multi-Method Assessment Fusion algorithm. Scores in VMAF range from 0 to 100, with 100 being excellent, 80 being good, 60 fair, 40 poor, 20 bad, and 0 representing a complete failure.

For our testing, we chose to target specific bitrates, since that's important for streaming. We tried to improve the quality where possible, provided it didn't kill the performance. AMD, for example, has three quality presets available—speed (the default), balanced, and quality.

We opted for the balanced mode, which was only slightly slower than speed but tended to improve the VMAF score by 5 to 10 percent. However, quality mode cut speed in half and only provided another one or two percent improvement, so we didn't use that. We also specified a key frame interval of two seconds (-g 120), to try to level the playing field and make the resulting 'streams' as universally supported as possible.

Here are the specific commands we used for our encoding and VMAF tests, where [source] was a high-quality 100Mbps H.264 video (40Mbps for 1080p), and [encoder] varies by GPU or CPU. For the CPU, we used libx264, libx265, and libsvtav1. AMD GPUs used h264_amf, hevc_amf, or av1_amf; Intel GPUs used h264_qsv, hevc_qsv, or av1_qsv; and Nvidia GPUs used h264_nvenc, hevc_nvenc, or av1_nvenc. [output] is the destination encoded file, and the other bracketed items are instructions for VMAF.

```
ffmpeg -i [source] -c:v
[encoder] -b:v [bitrate] -g 120
-y [output]
```

```
ffmpeg.exe -i [source]
-i [output] -lavfi
[0:v]setpts=PTS-
STARTPTS[reference];[1:v]
setpts=PTS-
STARTPTS[distorted];
[distorted] [reference]libvmaf
-f null-
```

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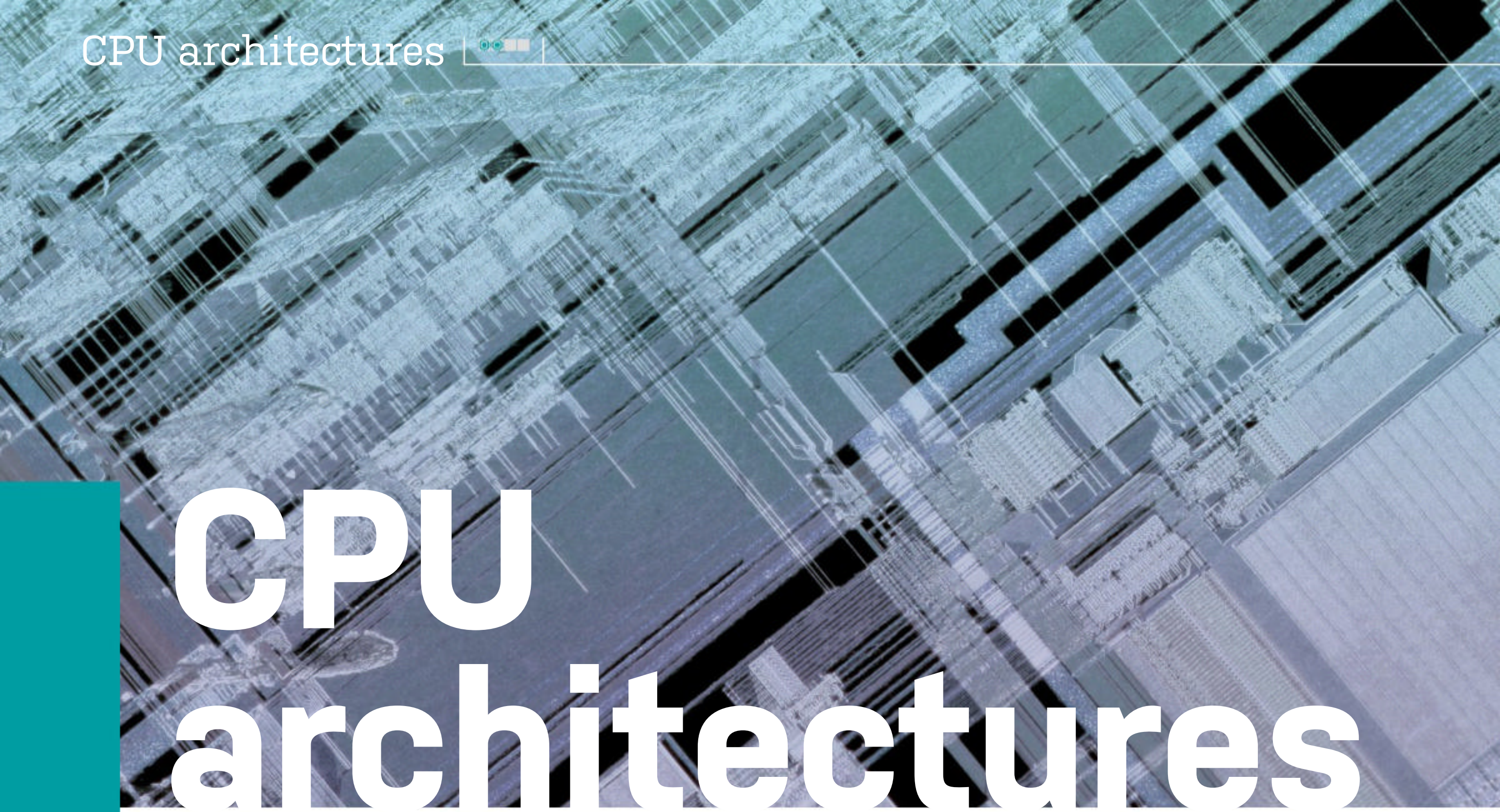
UPSTREAM BANDWIDTH MATTERS

We mentioned how cheap storage is for video archival purposes, so opting for higher bitrate video encodes to improve the quality isn't really an issue if you're only storing files for archival purposes, or building your own media server with thousands of movies.

For livestreaming, however, the bitrate can be a critical consideration, and it's largely going to depend on what sort of internet connection you have. Those of you with symmetrical gigabit fiber connections can just laugh and move on, but the rest of us probably have far more downstream bandwidth than upstream.

My personal connection currently consists of 1Gbps down and 20Mbps upstream bandwidth. Thankfully, I don't have a data cap, but 20Mbps means I'm best off capping video bitrates to 16Mbps — and that needs to include audio as well, though that's usually only 128kbps. Many cable providers won't even offer 20Mbps, with 12Mbps or even 10Mbps upstream limits still being common. Basic internet connections with 50Mbps downstream bandwidth often only have 7Mbps upstream, which would limit you to 6Mbps encodes at best, while a budget 25Mbps down/3Mbps also exists. Even watching videos on a 25Mbps stream can be problematic at times.

Unfortunately, in many cases, the only way to increase your upstream bandwidth will be to throw money at the problem, and outside of large metro areas even that might not suffice. There's always Starlink, though that also gives expected upstream speeds of just 10–20Mbps. If AV1 does become the new standard for streaming, though, 1080p streams with just 6Mbps should provide very good overall quality. ⏻



CPU architectures what's the difference and why it matters

Apple, AMD, and Intel all take different approaches to building CPUs. *Darien Graham-Smith* explains why

If you're considering buying a new computer, there are currently two main processor architectures to choose between. Windows PCs are normally built on the x86 platform, which is used by both Intel and AMD, while Apple's computers use the company's M1 and M2 processors, based on the ARM architecture.

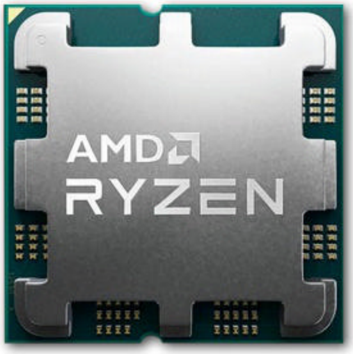
The x86 and ARM processor platforms do the same basic job, but they do it in slightly different ways. Their internal logic is wired up in different arrangements, with different configurations of internal data registers and different sets of hard-coded instructions. At a fundamental level, they run programs in different ways and use different code.

Over the next few pages, we will explore the main differences between the approaches of these two different architectures, and what that means in practice.

Instruction sets

On the x86 platform, the internal structure and instruction set of the processor is ultimately based on that of the Intel 8008, an 8-bit CPU that was launched in 1972. In fact, machine code programs written for that chip can still be assembled and run on the latest processors from Intel or AMD.

Naturally, though, the hardware has evolved considerably since then. After the 8008 came the 8088,



FAR LEFT **Apple's M-series CPUs have used a 5nm process since 2020.**

LEFT **All of Intel's x86 chips use the same underlying architecture.**

RIGHT **AMD's chips use the same core x86 architecture.**

and then the 16-bit 8086, which powered the original IBM PC. In the 1980s, this was followed by the 80186, 80286, and so forth—hence the "x86" name.

Through the generations, new features have been introduced to support multitasking and virtual memory. Support has also been added for 32-bit and 64-bit operations, enabling computers to work efficiently with huge data sets and massive amounts of RAM. A series of extensions has accelerated specific tasks, such as graphics processing, virtualization, and data encryption.

Apple's processors are based on the competing ARM architecture. This originated at Acorn Computers in the mid-1980s, at a time when the company was looking to create a successor to the hugely popular BBC Micro. Rather than buying chips from an external supplier, as it had with its previous home computers, the company set out to design a new processor that would outperform existing rivals. And it succeeded—at launch, the ARM-based Acorn Archimedes was the most powerful home computer money could buy.

Today, the ARM platform is owned and developed by Arm Limited in Cambridge in the United Kingdom, and like x86, it has continued to grow since its inception. Successive versions of the platform have added 64-bit support and numerous extensions to speed up common mathematical operations, including, in the latest ARMv9 release, security, and AI features.

RISC vs. CISC: The eternal rivalry

While ARM processors can do anything that their x86 counterparts can, they have different strengths and weaknesses as they follow a different design philosophy, known as RISC. The name originally stood for "Acorn RISC Machines", then later changed to "Advanced RISC Machines" as the market expanded beyond its original creator.

RISC, which stands for "reduced instruction set computer", is an idea that became popular in the 1980s and 1990s. This was a period when Intel and other chip makers were building more and more features and functions into the silicon, enabling programmers to execute complex operations with just a few lines of code. These processors came to be called CISC chips, for "complex instruction set computer".

The RISC philosophy takes the opposite approach, aiming to make a CPU as simple as possible, by reducing it to a bare minimum of basic functions. The ARM architecture uses just 34 instructions, which mostly handle simple mathematical operations and move data between registers and memory locations. By contrast, the Intel 8086 supported 81 instructions, permitting far more advanced data operations—and with subsequent revisions and extensions, that has ballooned to more than 200 instructions.

The RISC approach may seem counterintuitive. The smaller instruction set means that programs need to be longer and more complex to achieve the same results. However, a RISC chip can have a much simpler physical design than a CISC one, making it easier and cheaper to manufacture. It can tear through instructions at a faster rate—in most cases, every operation is completed in a single clock cycle. It consumes less power too, which is why ARM processors are dominant in mobile phones and tablets, where battery life is key.

While the CISC and RISC approaches are somewhat opposed, the differences aren't as important as you might imagine. Few programs are written in pure assembly language these days, so developers don't need to worry about the underlying architecture: they can write in Python, C#, or whatever language they choose and let the interpreter or compiler deal with the translation. In fact, Apple's ARM-based Macs include a real-time translation layer that lets them run programs written for x86 systems with no modifications.

The differences in power consumption are also smaller than they used to be. For many years, Intel struggled to match the low power consumption of ARM chips, not only because of the complexity of its processor designs but also because its in-house manufacturing facilities were unable to reduce the size of the transistors inside its chips as fast as its rivals. That's been a point of some embarrassment—the latest Intel chips are still using a 10nm fabrication process (dubbed "Intel 7"), while Apple's M-series processors have been using a 5nm process since their launch in 2020.

To help out, Intel's 12th generation Alder Lake processors, released at the end of 2021, introduced a heterogeneous core design. Whereas previous Intel chips typically featured four or eight identical cores, current models combine lightweight efficiency cores (E-cores) with powerful performance cores (P-cores) that only roar into life when they're needed for the most demanding tasks. This idea was pioneered by ARM—it introduced what it called the "big.LITTLE" design in 2011—but now Intel is onboard, we're frequently seeing Windows laptops

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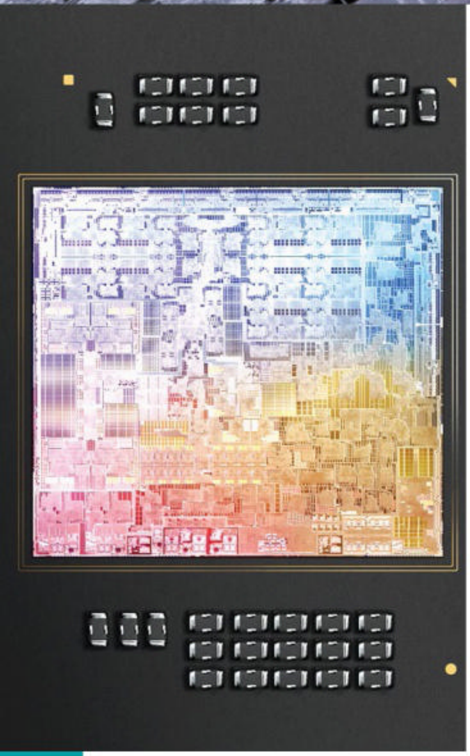

that can provide more than ten hours of continuous video playback. Even so, few Windows machines can match the 20 hours of the M2 Pro-powered MacBook Pro 16in.

Who makes what

Aside from the architectures, another notable difference between the two major computing rivals is that, unlike Intel, Arm doesn't make any processors of its own. Rather, the company licenses its designs to companies that can then customize them as desired, and have them manufactured to their own specification. In the case of Apple Silicon, Apple uses the core ARM logic but adds many of its own optimizations, and outsources the actual manufacturing to TSMC.

The way chips are marketed to end users is different, too. While all of Intel's x86 processors use the same underlying architecture, it's offered in an enormous number of different configurations. Within each generation of Core CPUs, there are Core i3, i5, i7, and i9 variants, which further subdivide into ranges of different models aimed at mobile, desktop, or gaming systems. They all have different numbers of processing cores, different amounts of cache memory, different clock speeds, and different power requirements. It's confusing, and when you're choosing a computer, there's a risk that you could choose a model that's underpowered for your needs.

Apple, by contrast, offers only five computer chips in total, namely the M1, M1 Pro, M1 Max, M1 Ultra, and M2. It's a much simpler lineup than Intel's, and even the regular M1 is competitive with a mid-range Intel chip. We found the original M1-powered MacBook Air achieved a multi-core Geekbench 5 score of 7,581, while the brand-new Surface Laptop 5, equipped with an Intel Core i7-1255U processor, turns in an almost identical 7,522. If you're comparing a range of systems, it's generally an advantage for Apple.

All aboard the memory bus

There's one final major difference between Apple's chips and Intel's, though this one isn't intrinsic to the ARM architecture, rather it's a design decision that Apple has taken. Whereas Intel's chips rely on external system RAM, Apple has incorporated the memory directly into the silicon die for its M-series processors.

This means you can't upgrade the memory on an Apple Silicon computer, which can lead to some agonizing decisions when it comes to choosing a specification. It also means that large allocations of memory aren't available on the mainstream chips—the M1 is offered with a maximum of 16GB RAM, while the M2 is limited to 24GB. If you want 32GB or more you need to move up to an expensive M2 Pro or Max system (or the M1 Ultra). For comparison, all of Intel's 12th and 13th generation processors can use up to 128GB of RAM.

However, because Apple's RAM is located next to the processor logic and connected via the fastest possible fabric, its processors can access code and data quickly and efficiently. The standard M1 boasts a maximum memory bandwidth of 68GB/sec, while the M2 goes up to 100GB/sec. The recently launched M2 Pro and Max models go up to 200GB/sec and 400GB/sec respectively. With Intel, it depends on the specifics of the processor, RAM, and motherboard, but even the fastest Core i9 is limited to a theoretical maximum of 90GB/sec.

ABOVE LEFT **Apple's M2 processors offer outstanding power efficiency.**

BELOW **Intel's 12th gen Alder Lake CPUs combine E-cores with P-cores.**

What's more, Apple uses what it calls a "unified memory architecture", which means the whole range of memory can be directly accessed by either the CPU or the on-die GPU. This provides huge efficiency benefits compared with a conventional PC architecture, where the CPU and GPU each have separate memory banks, and can't work together on the same data without copying it back and forth. It's not just games that benefit, but any process that can take advantage of GPU functions, such as video editing and rendering.

What about AMD?

So far we've been comparing Apple to Intel but, of course, there's a third major player in the CPU market. AMD's chips don't have such a distinct identity, however, as they use the same core x86 architecture and instruction set as Intel.

You may be wondering why Intel allows its biggest rival to use its proprietary architecture. The answer dates back to the early 1980s. At that time, IBM was interested in using Intel's chips in the original IBM PC, but didn't want to be reliant on one source of silicon—so it agreed to use x86 processors but on the condition that a second company was also permitted to manufacture hardware under license. So AMD was authorized to build Intel 8086, 80186, and 80286 processors.

AMD later drew on this expertise to start creating its own chip designs to rival Intel's. The K5 and K6, released in the late 1990s, provided x86 compatibility at a

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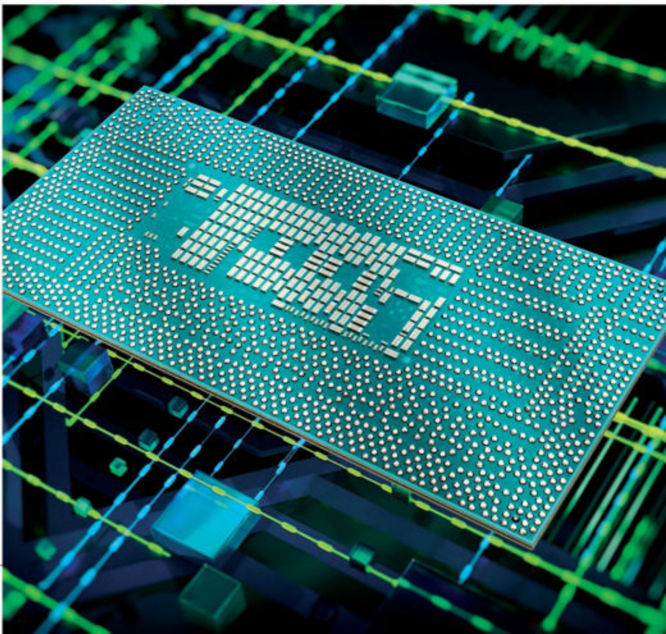


GONE BUT NOT FORGOTTEN

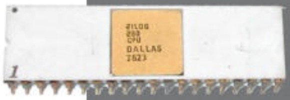
MOS 6502

MOS
6502AD
4585 S

Founded in 1974 by former Motorola employees, MOS Technology set out to create a new processor architecture that would out-compete Motorola's chips for a much lower price. With its focus on value, the 6502 became one of the most popular processors of the early home computing revolution.

Used in: **Apple II** (1977), **Atari 2600** (1977), **BBC Micro** (1981), **Commodore 64** (1982), **Nintendo Entertainment System** (1983)

ZILOG Z80



Similar to the MOS 6502, the Z80 was created in the mid-1970s by a breakaway group of chip designers—in this case, former Intel engineers. Although it could run programs written for the Intel 8080, the Z80 added many enhancements that made it more powerful and easier to program, making it attractive for personal computers and video games.

Used in: **Sinclair ZX Spectrum** (1982), **Amstrad CPC** (1984), **Amstrad PCW** (1985), **Sega Master System** (1985)

MOTOROLA 68000

With Intel's barnstorming 8086 CPU powering the IBM PC, rival Motorola knew it had to aim high to compete. It set out to create the most powerful processor on the market, creating a new 16-bit chip with cutting-edge 32-bit features. The 68000 was initially used in high-end workstations, but as costs fell, it became the foundation of a new generation of home computers.

Used in: **Apple Macintosh** (1984), **Commodore Amiga** (1985), **Atari ST** (1985)

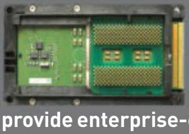
POWERPC

IBM PowerPC 601
PPC601FD-080-2

Jointly designed in 1992 by Apple, IBM, and Motorola, the PowerPC architecture was supposed to usher in a new era of RISC computing. Apple moved its whole Mac platform from Motorola chips to the PowerPC architecture, and the architecture was adopted by several game consoles. In the end, the PowerPC architecture couldn't keep up with Intel's performance, but it's still used for some roles, under the new name of Power ISA.

Used in: **Apple PowerMac** (from 1992), **Nintendo GameCube** (2001), **Microsoft Xbox 360** (2005), **Sony PlayStation 3** (2006), **Mars Rover Curiosity** (2011)

IA-64



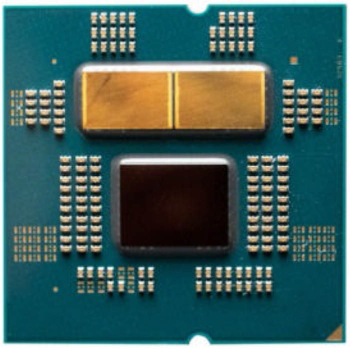
Created by Intel and HP in 2001, IA-64 was a 64-bit RISC platform designed to provide enterprise-class performance and scalability. Between 2001 and 2017 Intel launched ten generations of Itanium processors based on IA-64, but system builders favored the backward-compatible x86-64 extensions of AMD, and the Itanium line is now discontinued.

Used in: **Dell Precision Workstation 730** (2001), **HP ZX6000 workstations** (from 2001), **HPE Integrity servers** (from 2001)

lower price than Intel's Pentium processors. And at the turn of the millennium, AMD grafted a whole new 64-bit processing mode onto the x86 architecture, with enhancements to support working with larger numbers, bigger data sets, and more RAM. These extensions were then licensed by Intel, leading to a situation today where the two companies are effectively reliant upon each other. Intel lets AMD use the original x86 architecture, while AMD lets Intel use the 64-bit extensions. It's hard to see the benefit to either company of choosing to end the arrangement.

What makes AMD better than Intel?

Although AMD's processors can run the same programs as Intel's, there are some key differences. Although AMD sells its own chips, it doesn't manufacture them; this means it can use whichever foundry offers the best technology. While the first two generations of Ryzen CPUs were produced by Global Foundries, AMD switched to TSMC in 2019 to take advantage of its 7nm fabrication process, and the latest Ryzen 7000-series chips use the company's 5nm process. It means that AMD chips spend more of their time running at the highest frequencies before they need to slow down and cool off.



LEFT **AMD tends to pack in more performance cores than Intel.**

AMD's designs also frequently pack in more performance cores than similarly priced Intel chips, in part due to its "chiplet" approach. Rather than build everything onto one die, the design is broken down into multiple processor cores (chiplets) that are connected, along with shared resources, such as the main memory cache.

Actual core counts can be misleading, as both companies use multi-threading technologies that allow a single core to service two execution threads at once. Matters are further confused by Intel's recent adoption of efficiency cores, which don't contribute to peak performance.

Overall, though, you'll normally get more multicore processing power from an AMD chip—and to support those cores, AMD tends to provide more on-chip memory than Intel. While Ryzen processors don't put the whole RAM allocation on the chip die like Apple's chips, they generally have large caches that help them keep processing data and instructions at full speed, without having to wait for data to be fetched from the DIMMs.

The only question is how valuable multicore performance really is. Big database servers and graphics rendering programs may benefit from parallel processing power, but many games and desktop apps are mostly single-threaded. In practice, you might get a better experience with fewer, faster cores.

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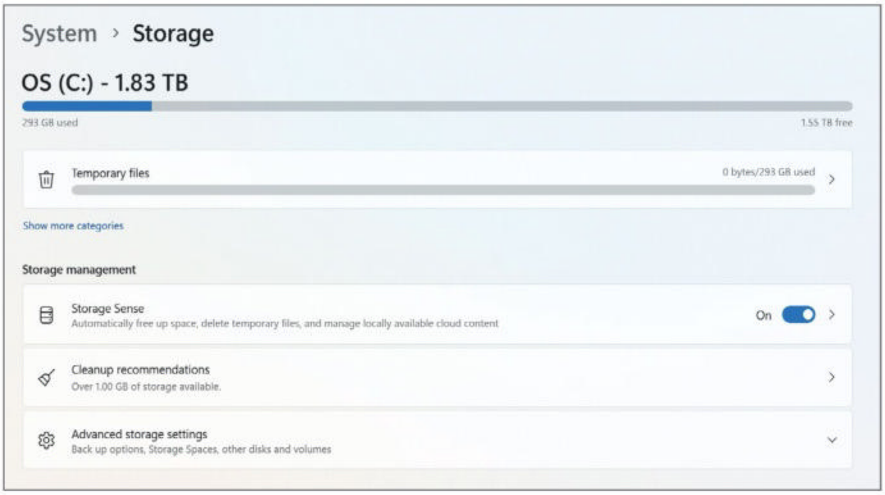
HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

TIP OF THE MONTH



System › Storage

OS (C:) - 1.83 TB

293 GB used 1.55 TB free

Temporary files 0 bytes/293 GB used

Show more categories

Storage management

Storage Sense
Automatically free up space, delete temporary files, and manage locally available cloud content
On

Cleanup recommendations
Over 1.00 GB of storage available.

Advanced storage settings
Back up options, Storage Spaces, other disks and volumes

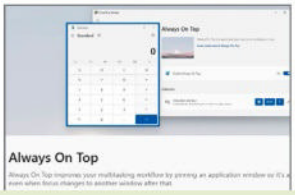
MAKE SENSE OF STORAGE SENSE

To ensure your PC is keeping your system as clean as possible, you can turn on the Storage Sense function. This will delete temporary files and cache, which automatically frees up space. Head into your OS settings, then Storage, and then toggle the Storage Sense switch. For additional settings, click on Storage Sense to open up all the options for scheduling, your recycling bin, and the downloads folder.

MAKE – USE – CREATE

Duplicati
Calibre Library
Home
Add backup
Restore
Settings
About
Log out

62
Create and manage bulletproof backups in the Cloud.



66
Boost Windows with Microsoft PowerToys tools.

General Information
Hostname
Domain
Primary DNS Server
Secondary DNS Server

70
Build your own Firewall in less than 30 minutes.

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SAM LEWIS
STAFF WRITER

A MINIMALIST APPROACH

In the previous issue, I spoke about my money-no-object rig—the Intel NUC 13, paired with the best GPU that works within this compact system, the RTX 4070Ti. I've come up with an alternative setup for the home. One of my most dependable laptops over the past year has been a Razer Blade 14 with an RTX 3080 GPU and an AMD Ryzen 6900HX. Although the display is great, with a 165Hz refresh rate and a QHD resolution, the 14-inch screen is too small for serious gaming. So, the next best thing is to pair it with a monitor.

I like everything to be minimal with no cables visible, so I came up with a clever solution—adding a hidden shelf for the laptop under my desk. I have one cable sleeve coming out of the back of this laptop, around the back of the desk, and into the monitor. This has similar specs to the laptop, with a lower refresh rate at 144Hz, but keeps the QHD resolution at a more practical 27-inches.

This setup has been good enough for both gaming and work. The shelf on which the laptop sits has plenty of space for ventilation and though I have to go under the desk, lift the lid, and hit the power button every time, that's my only small gripe. Although it isn't as good as the Intel NUC 13 with the RTX 4070Ti, it is more than powerful enough for me.

↘ submit your How To project idea to: editor@maximumpc.com

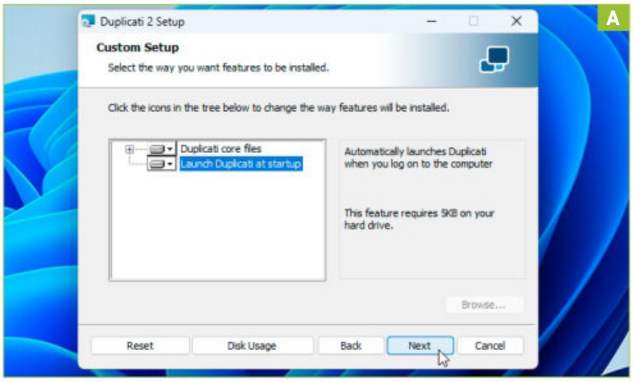
Create bulletproof backups in the cloud

YOU'LL NEED THIS

DUPLICATI
(www.duplicati.com)
Suitable online storage.
Duplicati supports most
popular services as well as
WebDAV, FTP, and SSH, and
can store backups locally too.

THE FIRST RULE OF BACKUPS is that you can't have too many backups. Better to have redundant copies of your data than a single copy that fails when you need it. Hopefully, you've already accumulated two separate backup devices, say a USB drive and network-attached storage, with backups alternating between them. You now need a third backup, stored offsite in case of fire, damage, or theft. The obvious choice is the online storage offered by Microsoft, Dropbox, or Google. But does your backup tool support cloud-based backups, and can you even trust your cloud provider—who controls the encryption keys that could unlock your data without consent?

Remove this worry by wrapping your backups in another layer of encryption, one whose keys remain in your possession, out of reach of others. The tool for the job is Duplicati—it's optimized for cloud backups, straightforward to use, and completely free. **–NICK PEERS**



Custom Setup
Select the way you want features to be installed.
Click the icons in the tree below to change the way features will be installed.
Duplicati core files
Launch Duplicati at startup
Automatically launches Duplicati when you log on to the computer
This feature requires 5KB on your hard drive.

1 DOWNLOAD AND INSTALL

Duplicati supports all major platforms—you'll find links for Windows, macOS, Linux (.deb and .rpm packages), and Synology NAS. Synology users can install the package directly, but other platforms require additional packages—Mono in the case of macOS and Linux, and both .NET Framework 4.6.2 and Visual C++ run-time components for Windows.

» Windows users can open Settings > System > Windows Update and view the Update history to verify if the .NET Framework is in place (look for updates related to .NET Framework 4.8.1), then navigate to Apps > Installed Apps and search for 'Visual C++' to see if a reference to Visual C++ 2015 (version 14.x) is present. If it is present, then you're good to go, but if not, visit (https://duplicati.readthedocs.io/en/latest/02-installation/) for installation instructions for all platforms.

» Once both are present, head to (www.duplicati.com/download) and choose the latest Windows build (2.0.6.3 at the time of writing). Once downloaded, double-click the installer and follow the prompts. Stick to the recommended defaults—leave 'Launch Duplicati at startup' enabled [**Image A**] and ensure 'Launch Duplicati now' is ticked before clicking Finish.

2 FIRST-RUN WIZARD

After a short pause, your web browser will open with a 'first run setup' wizard. First, you will be asked if you share your PC with others—if you are concerned about security, regardless of the state of your machine, click Yes to switch to 'Settings > Access to user interface'. Tick 'Password' to set a strong password (we recommend using your password's passphrase generator to create a lengthy, but memorable passphrase) [**Image B**].

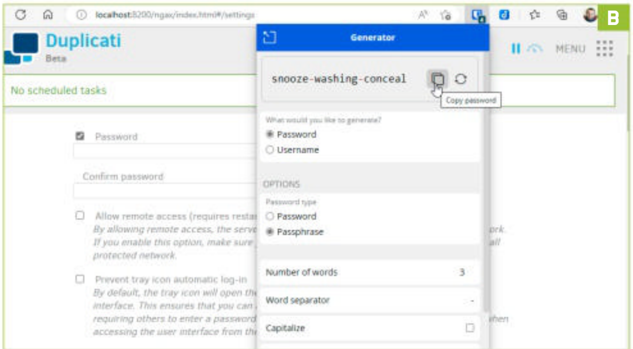
» While you're here, you will see an option to allow remote access. Ticking this allows you to access the Duplicati web interface from any other device on your network, which is essential if you're installing Duplicati on a headless server. You can then access the program from any web browser on your network, using http://192.168.x.y:8200, substituting 192.168.x.y with your PC's IP address. You might also wish to tick 'Prevent tray icon automatic log-in' for security reasons.

» Once done, scroll down and click OK. You'll see a 'Not logged in' message—click OK to enter the passphrase and then click Sign In to return to the main Duplicati screen, ready to configure your first backup.

3 SET BACKUP ENCRYPTION AND DESTINATION

Click 'Add backup', leave 'Configure a new backup selected', and click Next. The wizard opens to 'General backup settings'. Start by giving your backup a recognizable name and, if required, add an optional description that includes more details.

» Beneath this is the all-important encryption option—the built-in AES-256 encryption option is sufficient for most people's needs. Duplicati can generate a random 14-character password for you if you wish (make sure you store this somewhere safe, such as in your password manager), but if you're feeling ultra-paranoid, use your password manager to generate an even longer password or passphrase [**Image C**].



No scheduled tasks
☑ Password
Confirm password
☐ Allow remote access (requires resta
By allowing remote access, the serve
If you enable this option, make sure
protected network.
☐ Prevent tray icon automatic log-in
By default, the tray icon will open th
interface. This ensures that you can
requiring others to enter a password
accessing the user interface from th

snooze-washing-conceal
What would you like to generate?
● Password
○ Username
OPTIONS
Password type
○ Password
● Passphrase
Number of words 3
Word separator -
Capitalize ☐

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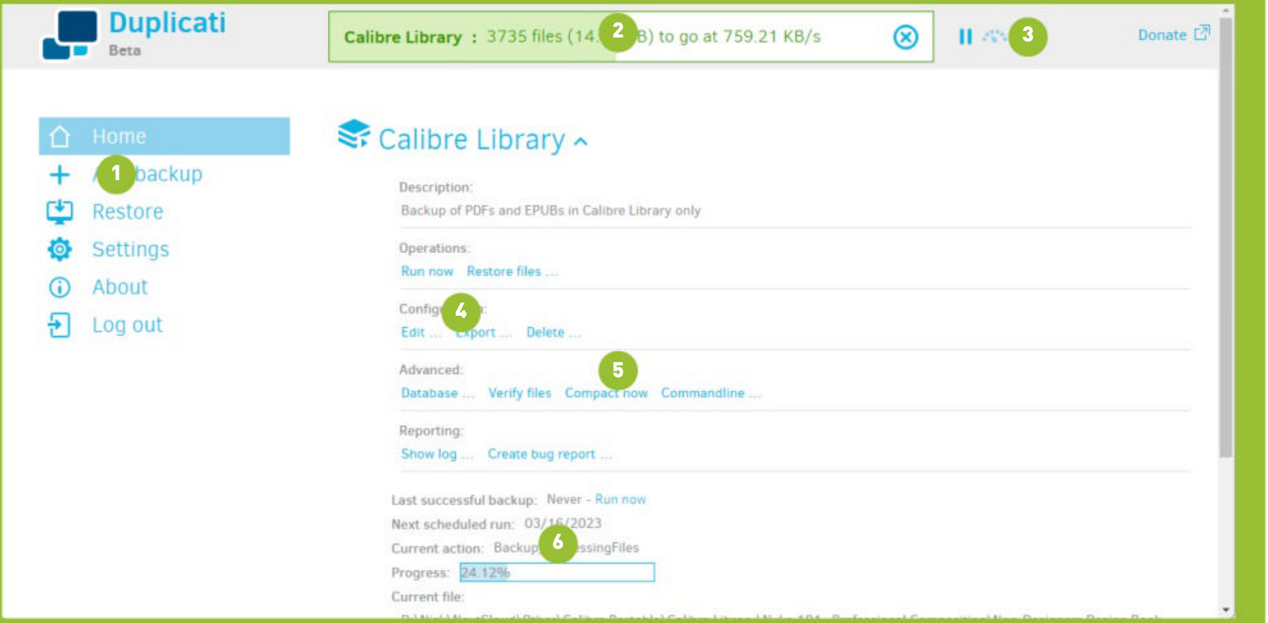
MANAGE CLOUD BACKUPS



Duplicati
Beta
Donate
Home
Add backup
Restore
Settings
About
Log out
1
2
3
4
5
6
Run now
Restore files ...
Edit ...
Export ...
Delete ...
Database ...
Verify files
Compact now
Commandline ...
Show log ...
Create bug report ...

Calibre Library : 3735 files (14.…B) to go at 759.21 KB/s

Calibre Library

Description:
Backup of PDFs and EPUBs in Calibre Library only

Operations:

Configuration:

Advanced:

Reporting:

Last successful backup: Never - Run now
Next scheduled run: 03/16/2023
Current action: Backup…ssingFiles
Progress: 24.12%
Current file:

1. KEY CONTROLS
Use these controls to create and restore backup jobs, plus tweak Duplicati's core settings. Click About to access system logs.

2. TRACK PROGRESS
This tracking bar gives you a clear indication of how your backup is progressing and how fast it is uploading to your cloud storage.

3. SET BANDWIDTH LIMITS
If your internet connection grinds to a halt while Duplicati is running, click the speedometer icon to set appropriate upload and download limits.

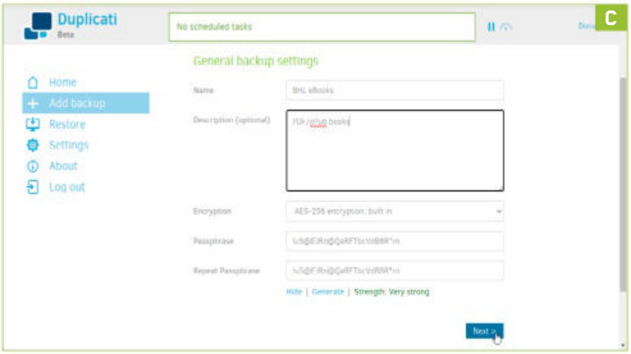
4. CONFIGURATION
Use these controls to edit the selected backup job, plus export it as a file for backup purposes.

5. ADVANCED FEATURES
Verify your backed-up files, compact or repair the underlying database and access command-line options for the backup job.

6. BACKUP SUMMARY
Get an overview of this backup job here—useful if another backup job is currently running, plus controls to manually run or restart it.

» Once set up, click Next to choose where to save this backup. The 'local folder or drive' option is selected by default, and all locally attached drives will be visible for selection. To back up to a network folder, click 'Manually type path' and then type the path you'd use for a direct connection – typically \\HOSTNAME\path or \\192.168.x.y\path.

» If the network folder requires authentication, enter your username and password, then click 'Test connection'—you should get a message saying 'Connection worked!' if the folder exists. Otherwise, you'll be prompted to allow Duplicati to create the folder if necessary.



C
Duplicati
Beta
No scheduled tasks
General backup settings
Home
Add backup
Restore
Settings
About
Log out
Name
Description (optional)
Encryption
Passphrase
Repeat Passphrase
Hide | Generate | Strength: Very strong
Next >

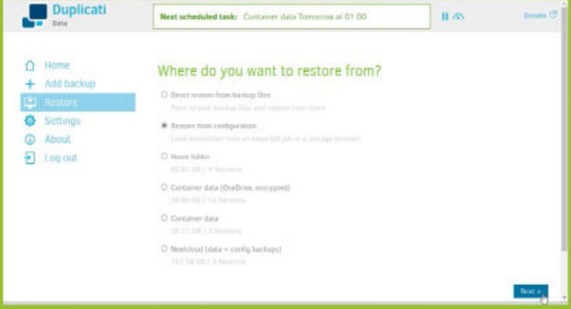
4 BACK UP ONLINE

To select an online destination for your backup, click the Storage Type dropdown. The options are split into two types—'standard' protocols, covering the likes of FTP and WebDAV, and SFTP (SSH). Depending on which option you select, you'll be presented with fields to fill in to make the connection. For example, FTP connections require a server and port, a path on the remote FTP server, plus a username and password.

» Beneath this is a long list of supported 'proprietary' protocols. These cover many popular cloud storage services, including OneDrive, Google Drive, Box.com, Dropbox, and Amazon S3-compatible storage. If you plan to use your personal or home Microsoft 365 storage, choose 'Microsoft OneDrive v2', then click the AuthID link to open a pop-up window that will connect Duplicati to your Microsoft 365/OneDrive account. Other providers work in a similar way, although you may need to supply more details, which you can obtain by visiting your cloud storage provider's help pages.

» You'll also need to manually specify the path to where you want your backups stored. If you're unsure, type /duplicati to create a dedicated folder on the root directory of your online storage before clicking 'Test connection'. Once confirmed, click Next to continue.

NON-STANDARD RESTORATIONS


Next scheduled task: Container data Tomorrow at 01:00

Where do you want to restore from?

○ Direct restore from backup files

● Restore from configuration

○ Home folder

○ Container data (OneDrive, encrypted)

○ Container data

○ Nextcloud (data + config backups)

If you're looking to restore data from Duplicati to a new computer or after reinstalling Windows, then you will need to install a fresh version of Duplicati. Once that's done, there are two options available. The first and simplest option is to make use of the exported configuration file you took in step 7. From the main Duplicati screen, select 'Restore > Restore from configuration' and click Next to select your backed-up configuration file and enter your password. On clicking Next, the backup job should be restored, and you can start the restoration process from there.

If you didn't back up the configuration file, it's a longer process but all is not lost. Choose 'Restore > Direct restore from backup files…' and click Next. You'll be presented with a similar wizard to the one that created the original backup. Choose the backup location—a simple folder selection in the case of a local or networked drive, or by reinputting the information and linking to your online provider.

You will need to enter the passphrase used to encrypt the backup. From here, you can select which files you want to restore and where to restore them, just as with other restoration methods.

5

SELECT WHAT TO BACK UP

Next, choose when you want to back up. Duplicati provides convenient shortcuts to your key user folders, including the hidden AppData\Roaming folder (marked as 'Application Data') where many programs store their user settings. Beneath this is the familiar Computer shortcut to all your drives, and there's an option to 'Show hidden folders' if you need it.

» Just click > next to an item to expand it. You can select multiple folders, subfolders, or files by placing a checkmark next to each one or you can simply select a top-level folder and explore the Filters and Exclude options to restrict what's backed up, if necessary. As you add check marks, the selected items will appear under Source data to help you see exactly what you have selected.

» The Exclude section enables you to strip out hidden system and temp files from your backups, along with any files larger than a specified size, which can be expressed in anything from bytes up to terabytes. Filters invites you to choose from a range of simple or sophisticated exclusions, from simple folders or files to including or excluding both simple and regular expressions. For example, let's say you only want to back up the actual eBook files (so PDF and EPUB) in your Calibre library, you'd create an 'Include expression' filter containing the string '+*.pdf +*.epub' [**Image D**].

» For a comprehensive look at setting up filters, see Duplicati's user manual (https://duplicati.readthedocs.io/en/latest/appendix-d-filters/). Once you're happy with your selection, click Next again.

6

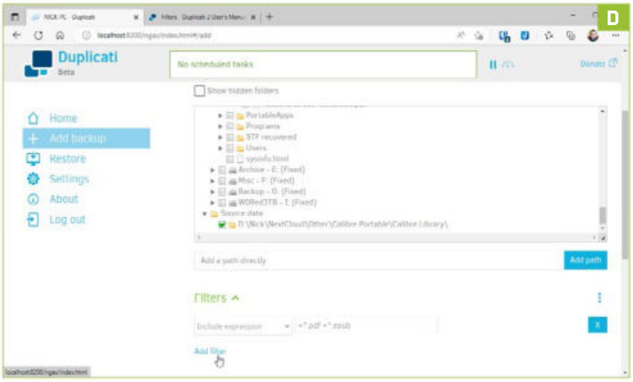
SCHEDULE AUTOMATIC BACKUPS

This step allows you to schedule regular backups of your data—leave 'Automatically run backups' checked, select a time and date for the first backup, then choose to run it again at selected intervals, ranging from minutes to years. From here, you can also specify which days the backup is allowed to run too [**Image E**].

» Click Next and you'll see two general options displayed. The first is the 'remote volume size', which refers to how your backup file is broken into manageable chunks for optimized uploading over the internet. By default, these volumes are 50MB in size, but you can increase the size of each volume to avoid hitting your online storage's file limits, albeit that comes with a greater risk of file corruption and slower restores. The rule of thumb is to only increase the volume size if you have a fast and stable internet connection and don't frequently find yourself restoring files from backups.

» The second option is 'Backup retention'. By default, all backups are kept and while Duplicati uses incremental backups for subsequent updates to your backup to minimize drive space, you may still wish to change this. Four options are provided, and the smart backup option is a good default choice.

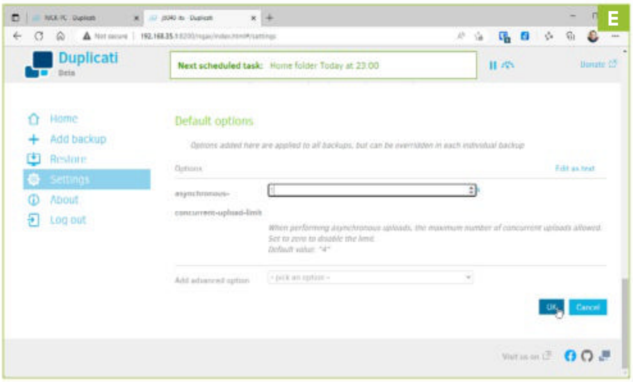
» Beneath the two general options, there is a collapsible 'Advanced options' section, containing a staggering number of additional tweaks for advanced users. For this tutorial, we're going to stick with the simple stuff as it's flexible enough for most people's needs, but there's a full list with definitions for reading as part of Duplicati's online manual (https://duplicati.readthedocs.io/en/latest/06-advanced-options/).


No scheduled tasks

☐ Show hidden folders

Source data: D:\Nick\NextCloud\Other\Calibre Portable\Calibre Library\

Include expression: +*.pdf +*.epub


Next scheduled task: Home folder Today at 23:00

Default options

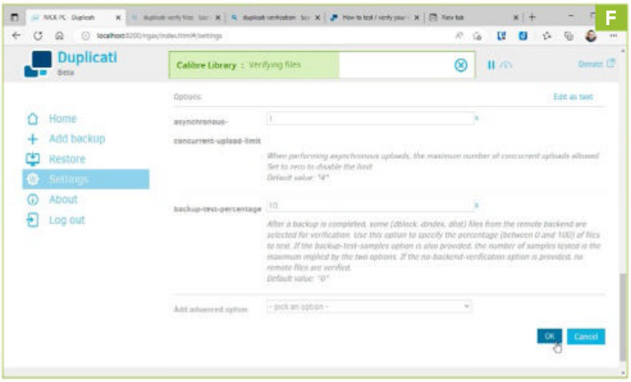
Options added here are applied to all backups, but can be overridden in each individual backup

asynchronous-concurrent-upload-limit

When performing asynchronous uploads, the maximum number of concurrent uploads allowed. Set to zero to disable the limit. Default value: "4"

Add advanced option: - pick an option -

© WWW.DUPLICATI.COM



asynchronous-concurrent-upload-limit: 1

When performing asynchronous uploads, the maximum number of concurrent uploads allowed. Set to zero to disable the limit.
Default value: "4"

backup-test-percentage: 10

After a backup is completed, some (dblock, dindex, dlist) files from the remote backend are selected for verification. Use this option to specify the percentage (between 0 and 100) of files to test. If the backup-test-samples option is also provided, the number of samples tested is the maximum implied by the two options. If the no-backend-verification option is provided, no remote files are verified.
Default value: "0"

7 YOUR FIRST BACKUP

Once you're happy with your backup selection, click Save. You'll be returned to the home screen where your first backup job will now be listed. Click 'Run now' to take your first backup, then click the ˇ button next to the backup job name to reveal lots more options.

» The first backup may take hours or even days to complete, depending on its size. If you find that uploading brings your internet connection grinding to a halt, click the speedometer button to set a maximum upload speed—no more than 75 percent of your total upload bandwidth—which you can get from (www.speedtest.net). Note that you will need to convert the figure from Megabits per second (Mb/s) to Megabytes per second (MB/s) by dividing it by eight.

» You'll also need to tick the 'Max download speed' box, which can be left at the default 10MB/s, then click Settings on the left, scroll down to 'Default options' and click 'pick an option' next to 'Add advanced option'. Select 'asynchronous-concurrent-upload-limit' under Core Options and set it to 1 as shown in [**Image F**]. Click OK, then click 'Run now' to start your backup.

» You can now leave Duplicati to its own devices. It's best to periodically check in to see how the backup is progressing, and in the meantime, protect your Duplicati backup configuration by taking the time to export it—expand your backup job's settings and click Export under Configuration. Leave 'To File' and 'Export passwords' selected, tick 'Encrypt file' (and supply a password) to protect it, then click Export. Store the file somewhere safe.

8 ADD MORE BACKUP JOBS

You can now move on to your second (and subsequent) backup jobs, following the same procedure we've outlined above. Complete your first backup job before running the second one—initial backups will always take longer than subsequent ones, because only the changes are recorded and added to the backup volume, resulting in faster (and smaller) backups.

» You can edit the backup settings at any time, so it might be worth skipping the scheduling of backups until each job has been completed once. Then you can expand each backup set in turn and click 'Edit' under Configuration to set up non-conflicting schedules—either on separate days or with a minimum of one to two hours between jobs.

» After a backup completes, a limited verification process is applied. This basically tests just one of the uploaded files to ensure it's working as it should. Visit (https://forum.duplicati.com/t/how-to-test-verify-your-backups/3700) to find out more about how the verification process works.

» If you want to verify more of the backup each time the job is run, add the 'backup-test-percentage' advanced option under Settings, then choose a suitable figure (10 percent ensures that the entire backup is tested over ten runs, for example).

9 RESTORE BACKUPS

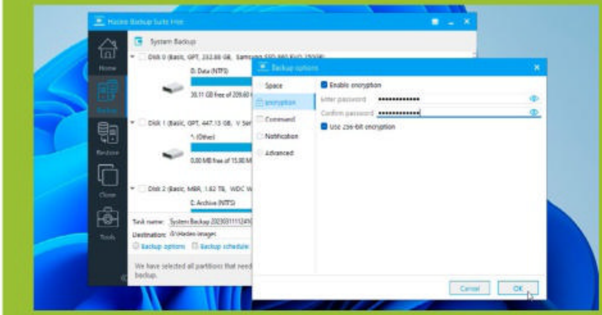
So, what if the unthinkable has happened and you need to recover some data that you've lost from your backup? If you've been forced to wipe your system and reinstall Duplicati, check the boxout on irregular restorations for details on how to recover your backups; otherwise, it's a simple task of opening Duplicati, clicking Restore, then selecting the relevant backup job and clicking Next.

» Whichever restoration option you choose, you can then select which folders to restore using the file picker—just tick the top-level folder to select everything in your backup. You can search for specific files and folders by keyword too.

» If you have multiple versions backed up, you can use the 'Restore from' dropdown menu to select an earlier version if you wish, although in disaster-recovery cases you'd usually leave the latest version selected.

» Once you've made your choice, click Continue. You can restore to the original location or select a folder path to restore to (click the Browse button). By default, existing files will be overwritten, but you can opt to save a copy with a timestamp in the specified location instead if you so wish. Look out for the 'Restore read/write permissions' box—ordinarily, you'll want to preserve these, so tick this before clicking Restore and waiting for the files to be copied back to your PC. ⏻

FILE ENCRYPTION ON THE HOP



☑ Enable encryption
Enter password: •••••••••••••
Confirm password: •••••••••••••
☑ Use 256-bit encryption

Duplicati makes use of AES encryption to scramble your backup files. Based on the free AES Crypt tool (www.aescrypt.com), you can use it as a standalone to encrypt (and decrypt) files on the fly—a perfect tool for storing or sharing sensitive files with others in an ad-hoc fashion.

Once installed on your PC, simply right-click a file and select 'AES Encrypt' from the 'Show more options' menu. Enter a strong password and click OK, then wait for an .aes file to be generated. This can be stored securely or sent to a trusted contact, with whom you've shared the password privately on a separate, secure channel. All they need to do is install AES Encrypt on their PC, then double-click the file you sent them. They'll be prompted for the password at which point a copy of the unencrypted file will be generated.

It's also worth checking your drive imaging tool to see if you can encrypt system backups—Hasleo Backup Suite users should select Backup Options > Encryption tab (check 'Use 256-bit encryption' for maximum protection), while Macrium Reflect users should click Advanced Options while editing their backup job and select Password. Again, select the 256-bit AES option for maximum encryption.

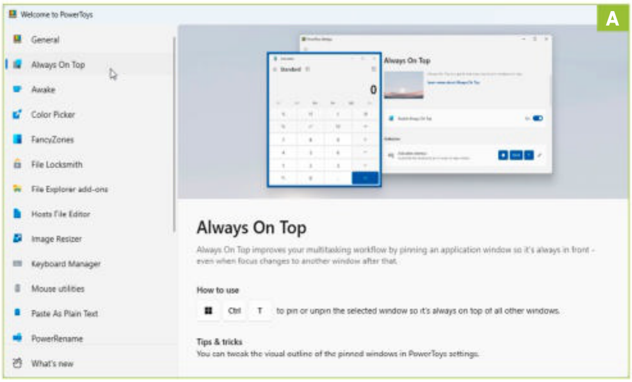
Boost Windows with Microsoft PowerToys

YOU'LL NEED THIS

WINDOWS 10 OR 11; MICROSOFT POWERTOYS a free and open-source download from either the Microsoft Store or Github (https://aka.ms/installpowertoys).

MANY OF THE BEST TOOLS are small and perfectly formed, but having to source them all from separate places, never mind manage them, can be a real pain, even for the most enthusiastic Windows tweaker. That's part of the rationale behind resurrecting Microsoft PowerToys, a disparate collection of tools that was originally released back in the days of Windows 95, and then later updated for Windows XP before being retired. But now they have been resurrected again in the style of the original Windows 95 release, as a single, unified package rather than a series of individual downloads.

In this tutorial, we're going to showcase some of the 18 tools and mini-apps that make up the PowerToys collection, drawing your attention to those we think are of the most interest to *Maximum PC* readers. But don't just take our word for it, why not install them yourself? The simplest way to install PowerToys on your PC is to search for it in the Microsoft Store, but you can also download the latest installer direct from its GitHub page. Most people will require the x64 version, but there is also an arm64 build available for compatible devices, such as Microsoft's SQ3 Surface Pro 9. **–NICK PEERS**



Always On Top

Always On Top improves your multitasking workflow by pinning an application window so it's always in front - even when focus changes to another window after that.

How to use

⊞ Ctrl T to pin or unpin the selected window so it's always on top of all other windows.

Tips & tricks

You can tweak the visual outline of the pinned windows in PowerToys settings.

1 FIRST STEPS

Launch PowerToys (https://aka.ms/installpowertoys) for the first time and a colorful icon appears in the Taskbar notification area. Clicking this reveals the Shortcuts pane, which is initially empty. Click the More button, and a complete list of PowerToys components will appear with a series of simple on/off sliders indicating whether the applet is enabled or not.

» An easier way to review PowerToys' available tools is via its Settings. Click the cog on the main Shortcuts screen or right-click the Taskbar notification area icon and choose Settings. This will open to the program's General settings page, which contains the usual set of configuration options, from checking for (and configuring automatic notification of) updates to backing up and restoring your PowerToys settings. It's all self-explanatory, so click the hamburger (≡) icon to reveal the components list where you can configure individual applets.

» However, before exploring this further, click 'Welcome to PowerToys' beneath it. This opens a new window with a handy preview of each applet, as shown in [**Image A**], what it does, how to use it, and a direct shortcut to its Settings pane. Take the time to work through the list.

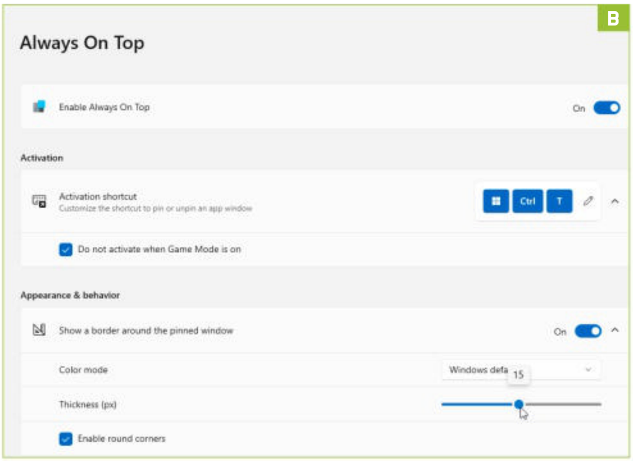
2 CONFIGURE INDIVIDUAL APPLETS

Once you have familiarized yourself with what PowerToys offers (new components are constantly being added via regular updates, so keep checking back after updates), it's time to explore some of the most interesting tools.

» Let's start with 'Always On Top' a handy tool that can be used to pin individual application windows so they always remain on top of others. The feature is enabled by default and you can test it by selecting a window and pressing Win + Ctrl + T. You'll hear a sound and the selected window will gain a visible border to help identify it. You'll notice as you open and close other windows it remains stubbornly on top.

» You can pin multiple windows (the last pinned window is always the one at the top) or select a pinned window and press Win + Ctrl + T again to disable the pinned feature so it behaves normally again. Now open the applet's Settings page where you'll find that all aspects of it can be configured as shown in [**Image B**].

» You can enable or disable the feature, change its shortcut, limit its behavior (for example, so that it's disabled when Game Mode is on), alter its appearance (the border, its color, and whether it's rounded or not), and create individual exclusions to prevent selected apps from being pinned.



Enable Always On Top: On

Activation shortcut: ⊞ Ctrl T
Customize the shortcut to pin or unpin an app window

☑ Do not activate when Game Mode is on

Show a border around the pinned window: On

Color mode: Windows defa

Thickness (px): 15

☑ Enable round corners

© MICROSOFT

3 HANDY SYSTEM TOOLS

Let's continue our tour by grouping the applets into two broad categories, starting with system tools. 'Awake' (disabled by default) lets you temporarily override your power saving settings via a Taskbar notification area icon, while 'FancyZones' takes window management to the next level by allowing you to create custom-sized zones for arranging and snapping windows.

» 'File Locksmith' helps you track down what process is currently locking a file or folder—simply right-click the errant file and choose 'Show more options > What's using this file?' to view a list, plus close the errant process to give you access to edit or delete the file as required. 'File Explorer add-ons' simply add support for previewing PDF, mk (markdown), and various developer file formats to File Explorer.

» 'Mouse utilities' adds useful features to your mouse, from 'Find My Mouse' (shake the mouse or press left Ctrl twice) to 'Mouse Jump' (move the mouse instantly to anywhere on your desktop). 'PowerRename' integrates bulk renaming into Windows via a shell extension, with support for regular expressions and other powerful naming conventions.

» Forgotten what Windows keyboard shortcut does what? Press Win + Shift + / and Shortcut Guide will pop up a handy overlay revealing what universal shortcuts are available and, in the case of the Taskbar shortcuts, they'll even point to the relevant app icon on the Taskbar as shown in [**Image C**].

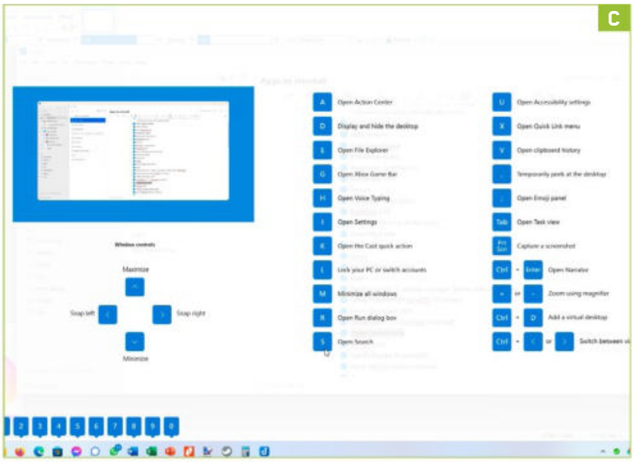
4 BOOST YOUR PRODUCTIVITY

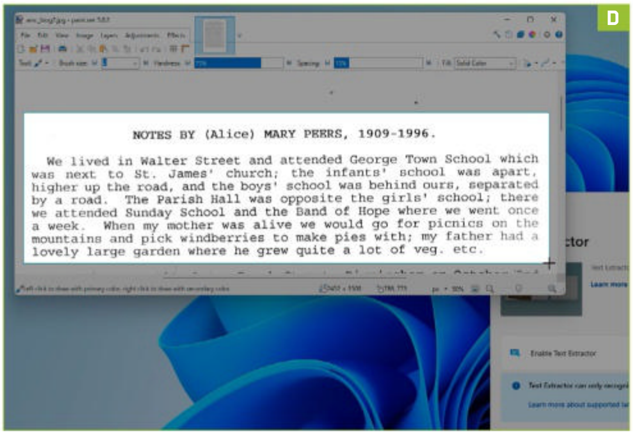
PowerToys is also packed with tools to help boost your day-to-day productivity. One of its standout features is 'Text Extractor', which allows you to pull editable text from images through clever use of OCR. Before you begin, you'll need to install an OCR language pack. Right-click the Start button and choose Terminal (Admin). In a PowerShell window, enter the following commands:

```
$Capability = Get-WindowsCapability -Online | Where-Object {
$_.Name -Like 'Language.OCR*en-US*' }
$Capability | Add-WindowsCapability -Online
```

» Once installed, Text Extractor works in a similar way to the Snipping Tool. First, bring up the image containing text on-screen – the larger the better. Then, press Win + Shift + T to click and drag a rectangle around the text part of the image as shown in [**Image D**] (hold Shift if you need to move the selection for any reason). Once captured, the screen will flash and the converted text is placed on the clipboard, ready for pasting elsewhere.

» Elsewhere, 'Color Picker' makes it easy to quickly select colors from any application window, then configure them in a clipboard-friendly format, from RGB to HEX. 'Image Resizer' allows you to quickly resize one or more files directly from File Explorer. When enabled, right-click the selection and choose 'Show more options > Resize pictures'. You can set your own custom sizes for quick selection or make precise adjustments each time.


C
Window controls
Maximize
Snap left
Snap right
Minimize
A Open Action Center
D Display and hide the desktop
E Open File Explorer
G Open Xbox Game Bar
H Open Voice Typing
I Open Settings
K Open the Cast quick action
L Link your PC or switch accounts
M Minimize all windows
R Open Run dialog box
S Open Search
U Open Accessibility settings
X Open Quick Link menu
V Open clipboard history
Temporarily peek at the desktop
Open Emoji panel
Tab Open Task view
Capture a screenshot
Ctrl + Enter Open Narrator
Zoom using magnifier
Ctrl + D Add a virtual desktop
Ctrl + or Switch between
2 3 4 5 6 7 8 9 0


D

NOTES BY (Alice) MARY PEERS, 1909-1996.

We lived in Walter Street and attended George Town School which was next to St. James' church; the infants' school was apart, higher up the road, and the boys' school was behind ours, separated by a road. The Parish Hall was opposite the girls' school; there we attended Sunday School and the Band of Hope where we went once a week. When my mother was alive we would go for picnics on the mountains and pick windberries to make pies with; my father had a lovely large garden where he grew quite a lot of veg. etc.

Enable Text Extractor

» Keyboard not working as you'd like? 'Keyboard Manager' allows you to remap keys and create your own keyboard shortcuts, while 'Paste As Plain Text' allows you to strip any text formatting from the clipboard so plain text is pasted into any application with a global keyboard shortcut (Win + Ctrl + V by default).

» PowerToys is constantly expanding its capabilities—'Paste As Plain Text' is the newest tool added to the mix, and with major updates appearing every month, it pays to keep a close eye on the tool's release notes (https://github.com/microsoft/PowerToys/releases). Remember, though, that PowerToys is still pre-release software, so expect some bugs.

TURBOCHARGE YOUR SEARCHES

Looking for a simple, but fast (and wide-ranging) search tool that doesn't shove Bing suggestions and ads down your throat? PowerToys Run may sound like it's an upgrade on the venerable Windows Run dialog, but just press Alt + Space to bring up a pop-up search box and start typing. You'll see it offers shortcuts to installed programs, indexed files, and folders, Run commands, and will even open web addresses in your default browser.

You can filter your searches using prefixes: "<" to search running processes only, "?" to exclusively search for files, and "." for installed apps. But this merely scratches the surface of what PowerToys Run can do. Open its settings and scroll down to discover it's powered by plugins, allowing you to remove existing functionality by disabling unwanted extensions or adding others.

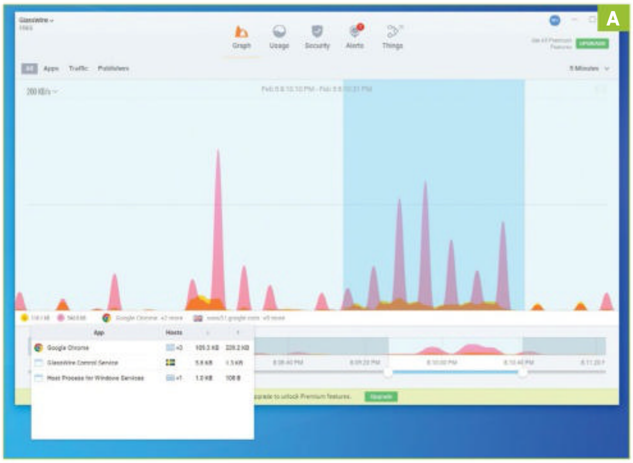
It's worth going through the list just to see what else PowerToys Run can do—use it for quick calculations or unit conversions, search the web using your browser's default engine, and more besides. As with all PowerToys, it's infinitely customizable (you may want to tweak the 'Number of results shown before scrolling' figure to display more than four results at once, for example).

Find and remove hidden tools

YOU'LL NEED THIS

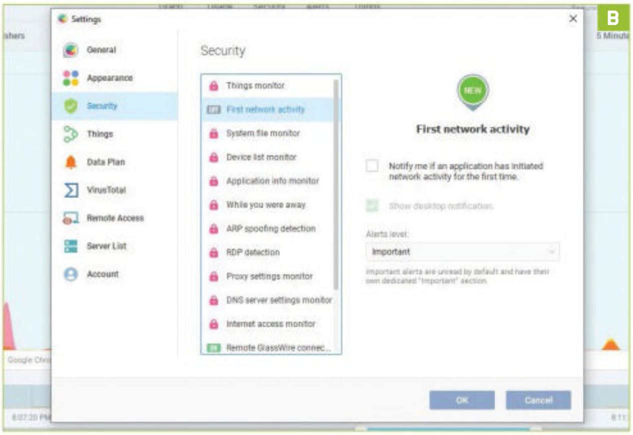
GLASSWIRE 3.2
(free), 20 minutes

EVER WONDERED HOW many programs on your computer are using your internet connection? Network-monitoring tool GlassWire shines a light on exactly what each online program is up to, helping you identify any dodgy tools that shouldn't be accessing the internet. Even better, the latest free version (3.2) includes a selection of powerful tools that were previously available only in the paid-for version. We'll explain how to use them here. **–NIK RAWLINSON**


A
Graph
Usage
Security
Alerts
Things
UPGRADE
All
Apps
Traffic
Publishers
5 Minutes
200 KB/s
Google Chrome
GlassWire Control Service
Host Process for Windows Services
Upgrade

1 GET GLASSWIRE

To install the latest version of GlassWire, go to www.glasswire.com/download, click the green Download button, then run the EXE file that downloads. Follow the installation process, then run GlassWire. The 'Graph' tab [**Image A**] will be displayed by default and shows all internet activity on your computer (orange sections represent data being downloaded, and purple shows uploads). The graph updates in real time and displays up to 24 hours of data (select the time period using the dropdown box, top right). To find out which programs were accessing the internet during a specific time period, click and drag across the relevant area on the graph. The program that was using your connection most in this period will now be displayed—hover over this to see a list of other programs.


B
Settings
General
Appearance
Security
Things
Data Plan
VirusTotal
Remote Access
Server List
Account
Things monitor
First network activity
System file monitor
Device list monitor
Application info monitor
While you were away
ARP spoofing detection
RDP detection
Proxy settings monitor
DNS server settings monitor
Internet access monitor
Remote GlassWire connec...
NEW
OK
Cancel

Security

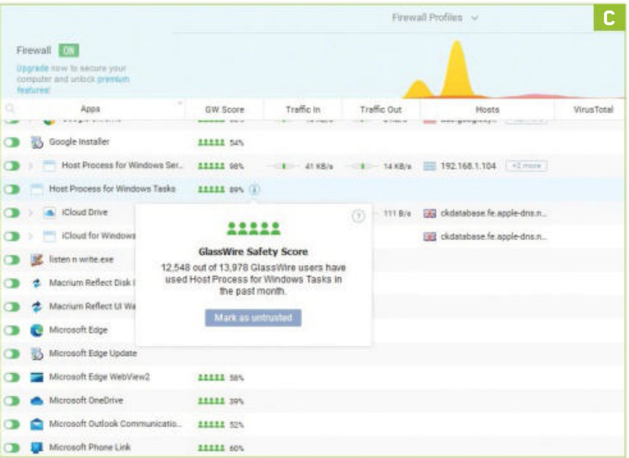
First network activity

☐ Notify me if an application has initiated network activity for the first time.

☑ Show desktop notification

Alerts level: Important

Important alerts are unread by default and have their own dedicated "Important" section.

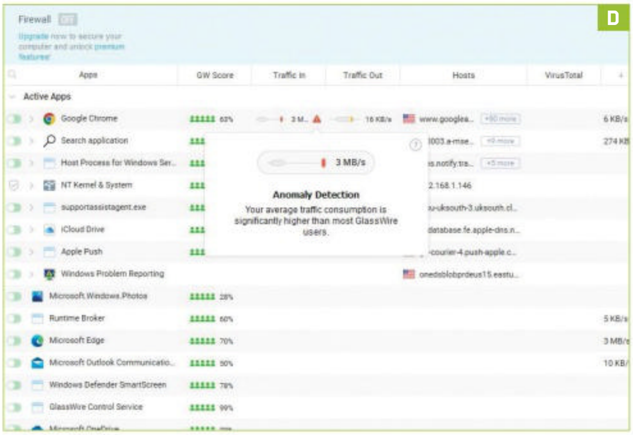

C
Firewall Profiles
Firewall ON
Upgrade now to secure your computer and unlock premium features!
Apps
GW Score
Traffic In
Traffic Out
Hosts
VirusTotal
Google Installer
Host Process for Windows Ser...
Host Process for Windows Tasks
iCloud Drive
iCloud for Windows
listen n write.exe
Macrium Reflect Disk I
Macrium Reflect UI Wa
Microsoft Edge
Microsoft Edge Update
Microsoft Edge WebView2
Microsoft OneDrive
Microsoft Outlook Communicatio...
Microsoft Phone Link
Mark as untrusted

GlassWire Safety Score

12,548 out of 13,978 GlassWire users have used Host Process for Windows Tasks in the past month.

2 RUN GLASSWIRE

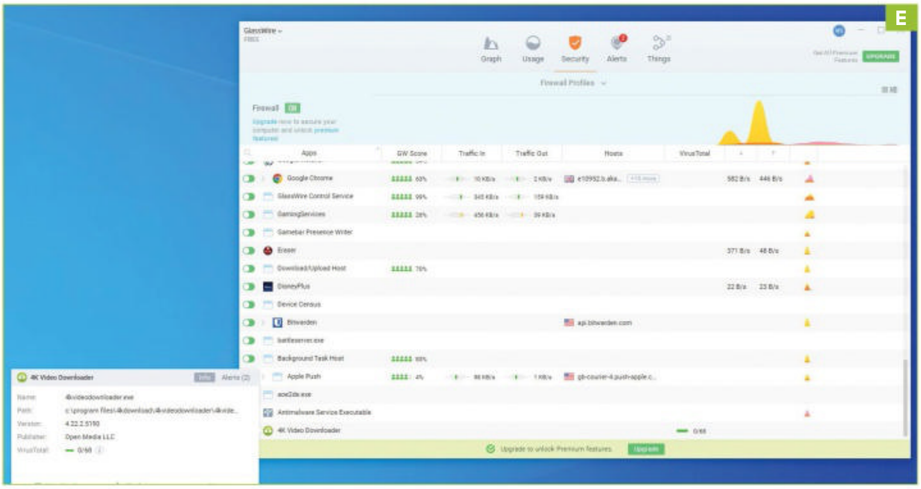
When you first run GlassWire, you'll see plenty of notifications about programs accessing the internet for the first time. Don't be alarmed, these messages appear because you've only just installed GlassWire—this should settle down once you've had it running for a few hours. If you prefer, you can hide these notifications—click the GlassWire button [**Image B**], then Settings followed by Security in the left-hand panel. Select 'First network activity', then untick the 'Notify me...' box. However, we recommend leaving them active, as they'll alert you to programs that you might not realise you had installed or ones you may not want accessing the internet.


D
Firewall
Upgrade now to secure your computer and unlock premium features!
Apps
GW Score
Traffic In
Traffic Out
Hosts
VirusTotal
Active Apps
Google Chrome
Search application
Host Process for Windows Ser...
NT Kernel & System
supportassistagent.exe
iCloud Drive
Apple Push
Windows Problem Reporting
Microsoft Windows Photos
Runtime Broker
Microsoft Edge
Microsoft Outlook Communicatio...
Windows Defender SmartScreen
GlassWire Control Service
3 MB/s

Anomaly Detection

Your average traffic consumption is significantly higher than most GlassWire users.

© GLASSWIRE



3 CHECK ACTIVITY

If you do spot a program that you don't like the look of, or you just want to find out how many programs on your computer are accessing the internet, select the Security tab [Image C] (one of the previously paid-for features that is now available for free). You'll now see all programs that have recently used your internet connection. The 'GW Score' column gives an indication of how popular each program is with GlassWire users. A low score means that relatively few GlassWire users have the program installed (hover over the score and click the 'i' icon for more details). Don't assume that any program with a low score is malware (it might just be relatively new or niche), but do investigate further.

4 DETECT ANOMALIES

GlassWire 3.2 includes another new free tool: Anomaly Detection. This monitors all programs that use your internet connection and flags any that suddenly see a spike in internet activity—an indication that the program might be under the control of malware. There are two columns [Image D]: Traffic In (which shows how much a program is downloading data to your computer); and Traffic Out (how much it's uploading). If a warning triangle appears next to either of them, it means that GlassWire has detected suspiciously high network activity. In our example, GlassWire has flagged Chrome as using our internet connection to download more data than what might reasonably be expected—on this occasion, it's simply due to us downloading a large file, so is nothing to worry about.

5 SQUASH VIRUSES

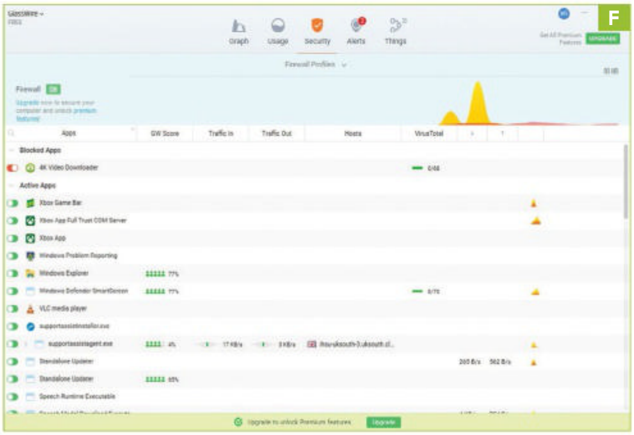
Another way to verify a program's authenticity is to check it with VirusTotal (Google's online service that lets you scan programs using multiple antivirus engines). First, enable VirusTotal scanning by going to the Settings window (as in Step 2), select VirusTotal on the left, then tick the 'Enable manual file...' box. Click OK and click the program you want to scan. A pop-up window will appear, displaying additional information about the program. Click the VirusTotal button [Image E]. After a few seconds, you'll see the VirusTotal score (here, '0/68' indicates that none of the 68 antivirus engines used by VirusTotal consider this program to be malware). If you find one that's flagged as potentially dangerous, click the 'i' icon to get more details from the VirusTotal website.

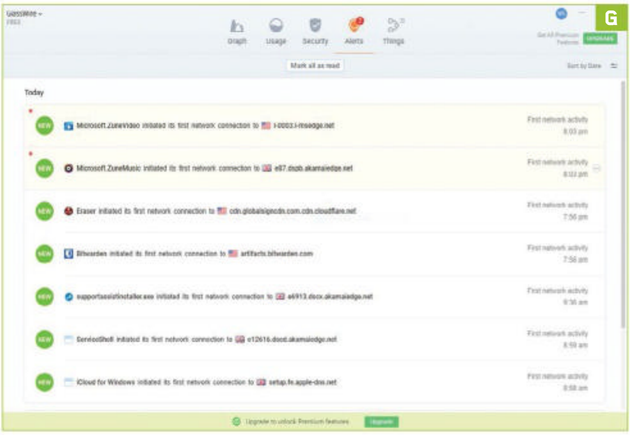
6 TERMINATE ACCESS

If you've followed the previous three steps and still don't trust a particular program, you can terminate its connection to the internet by clicking the slider to the left of its name. The first time you do this, you'll be prompted to turn on GlassWire's firewall (another tool that's now free). Once you've clicked the slider (turning it from green to orange [Image F]), the program will no longer be able to access the internet. If you later decide the program isn't a threat, reinstate its access by clicking the slider, turning it back to green.

7 CONTROL ALERTS

Depending on how many programs you have installed, you may receive a lot of alerts and messages. Click the Alerts tab [Image G] to review messages generated by GlassWire over the past 24 hours (you'll need the paid-for version to view older messages)—unread messages are marked with a red dot. GlassWire also lets you find out how many devices are connected to your home network. Select the Things tab, then click Scan. You'll see a list of devices. The 'Details' tab lists additional information for each, such as the device type and manufacturer (if known).





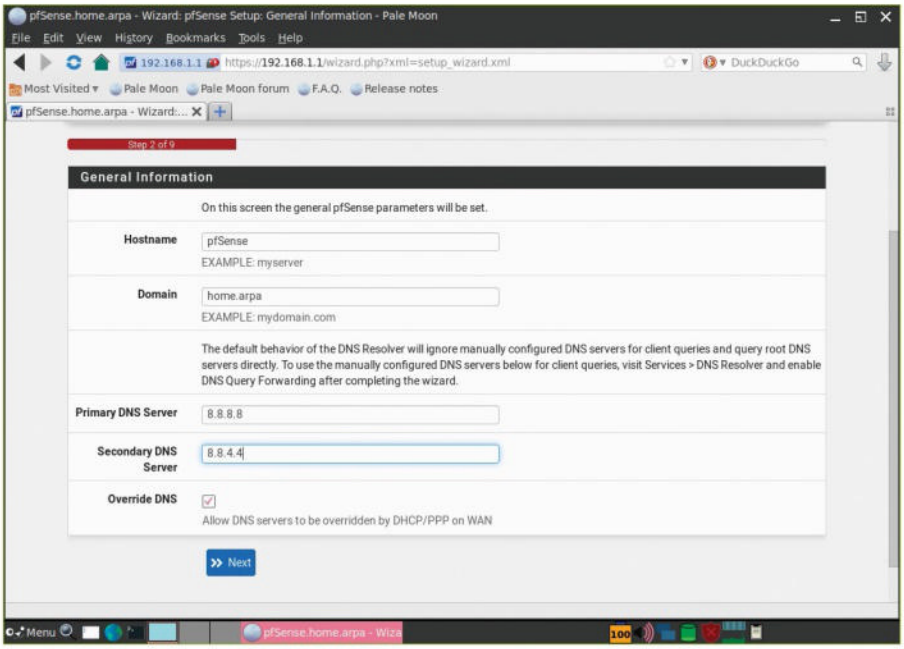
Build your own firewall in 30 mins

YOU'LL NEED THIS

PFSENSE FIREWALL
(free)

YOU MIGHT NOT THINK you need another firewall. The one built into Windows is working all the time in the background to protect individual computers, and many routers have their own firewalls to protect the whole network. But running your own custom firewall has several benefits: it gives you more flexibility, plus better oversight of what's going on in the background.

It's also easier to set up than you might think. You don't need specialist hardware, and you don't need to pay for firewall software. The open-source pfSense firewall is free for personal use, with a graphical interface for administration and all the same features as the enterprise version (the difference is that you don't get commercial support). You can run it in a virtual machine on any PC on your network, or install it natively on a retired PC. Note, though, that you can't run pfSense on a Raspberry Pi, as it doesn't support the ARM architecture. –**NIK RAWLINSON**


pfSense.home.arpa - Wizard: pfSense Setup: General Information - Pale Moon
File Edit View History Bookmarks Tools Help
192.168.1.1 https://192.168.1.1/wizard.php?xml=setup_wizard.xml
DuckDuckGo
Most Visited Pale Moon Pale Moon forum F.A.Q. Release notes
pfSense.home.arpa - Wizard:...
Menu
pfSense.home.arpa - Wiza

Step 2 of 9

General Information

On this screen the general pfSense parameters will be set.

Hostname: pfSense
EXAMPLE: myserver

Domain: home.arpa
EXAMPLE: mydomain.com

The default behavior of the DNS Resolver will ignore manually configured DNS servers for client queries and query root DNS servers directly. To use the manually configured DNS servers below for client queries, visit Services > DNS Resolver and enable DNS Query Forwarding after completing the wizard.

Primary DNS Server: 8.8.8.8

Secondary DNS Server: 8.8.4.4

Override DNS: ☑ Allow DNS servers to be overridden by DHCP/PPP on WAN

» Next

» Use Google's DNS servers if you don't know your ISP's.

1 GET PFSENSE

The pfSense firewall installs as a complete operating system based on FreeBSD. This means you'll need to allocate at least 512MB of memory and have a 64-bit processor running at more than 500MHz. If you want to support gigabit Ethernet or faster connections, it's recommended to use a system with multiple cores running at speeds in excess of 2GHz.

» You can download the installer from pfsense.org/download. You'll want the AMD64 code (which is also compatible with Intel processors)—Netgate ADI is for dedicated firewall hardware. It's up to you whether you choose a DVD image or a USB memory stick installer—for a virtual machine, the DVD option is easiest, but if you're devoting a PC to the task of running the firewall, the USB installer will probably be more convenient.

2 CREATE YOUR INSTALLATION MEDIA

If you've chosen the USB installer option, you'll need a tool to write the image onto a flash drive. We used Balena Etcher, which you can download from balena.io/etcher.

» If you want to install to a virtual machine, you'll need the free 7-Zip tool from 7-zip.org to extract the image to a convenient destination folder. For installation on a virtual machine, you don't need to do any more at this stage, but if you want to create an installation DVD, right-click the decompressed ISO, click "Burn disk image", then select your DVD writer. Insert a blank DVD and click Burn.

3 BOOT THE INSTALLER

If you're using an old PC, this starts with booting it up from your newly imaged DVD or USB flash drive. Go into the BIOS configuration pages after plugging in the USB drive to set it as the top-priority boot device.

» If you're installing in a virtual machine, create a machine with sufficient resources. We used VirtualBox, with the OS type set to "Linux" and the version set to "Other Linux (64-bit)". We'd recommend going beyond the minimum requirements and giving the virtual machine at least 1GB of memory, although you'll have to balance this with the resources you need to reserve for general use.

» Once your machine has been created, select it and click Settings, then Network in the sidebar. Make sure the option to Enable Network Adapter is ticked on each of the tabs for Adapter 1, Adapter 2, and Adapter 3. On the Adapter 1 tab, select NAT from the "Attached to" menu and, on the other two tabs, select Internal Network.

» Finally, "insert" your DVD image into the virtual drive of your new machine. Click Storage in the sidebar, then click the DVD icon under Storage Devices, followed by the smaller DVD icon to the right of the Optical Drive menu in the Attributes section. Select the ISO file you just unpacked, then click OK to close Settings. Now, click Start to boot the virtual machine.

© PFSENSE FIREWALL

4 INSTALLING PFSENSE

The pfSense firewall uses a text-based installer. Agree to the disclaimers (if you're happy with them), and choose your keyboard language. You now need to partition the hard drive. With BSD-based installations, the default filing system is ZFS, but you can change this to UFS. We'll stick with ZFS, so with "Auto (ZFS)" selected, press Return. On the following screen, leave the configuration options in their default state and press Return—assuming that you want your data to be "striped" on a single drive with no redundancy. If you want to set up a RAID array on a physical system, you can set up mirroring and redundancy.

» pfSense will then extract the distribution files and configure the operating system. Once it's finished, it offers to open the command shell so you can make any final manual modifications; unless you want to do this, leave No highlighted and press Return.

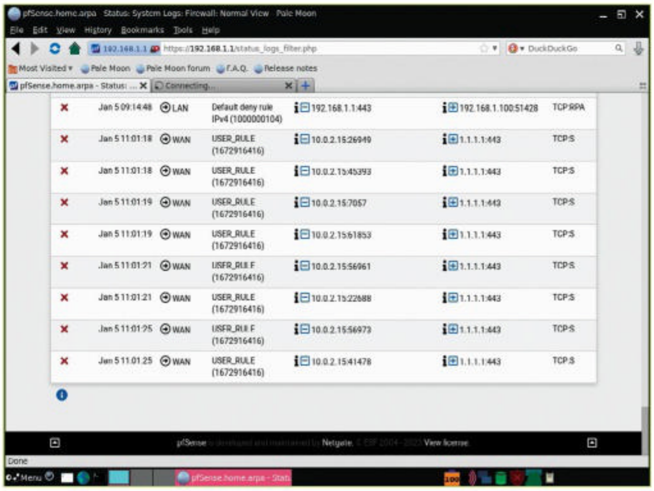
» If you're using physical hardware, now's the time to remove your USB flash drive, before pressing Return again to reboot. If you're installing within a virtual machine, press Return, and when the system has finished rebooting, close the window to power off the machine.

5 CONFIGURE PFSENSE

To configure the firewall, log in to pfSense from another machine on the same network. With a virtual machine, the easiest way to do this is to set up another machine within the same host and set its Adapter 1 network connection to Internal Network, as you did for adapters 2 and 3 when setting up the pfSense host. This machine will need its own operating system: we used Puppy Linux (puppylinux-woof-ce.github.io), as it's a lightweight distribution, which shouldn't compete too much with the firewall for resources.

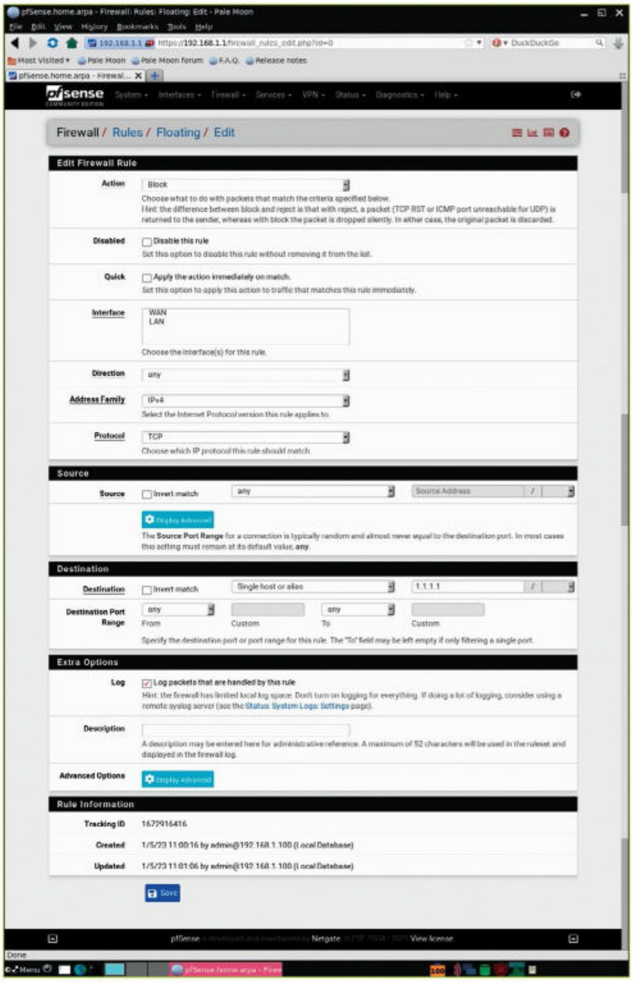
» Open a web browser, navigate to the address of your pfSense installation—normally 192.168.1.1—then log in with the username "admin" and the password "pfsense".

» You should now see the pfSense setup wizard. Click Next on the first page, and on the second, specify the primary and secondary DNS servers you want to use. You can use your ISP's servers if you know their addresses, or a free service such as Google Public DNS, at 8.8.8.8 and 8.8.4.4. Step through the rest of the wizard, making sure you change the admin password, then wait for the firewall to restart. When it does, the browser will refresh and pfSense will be ready to use. You also need to make sure there are no competing DHCP servers on your network, so turn off this capability in your router's settings page.


pfSense.home.arpa   Status: System Logs: Firewall: Normal View   Pale Moon
File Edit View History Bookmarks Tools Help
https://192.168.1.1/status_logs_filter.php
DuckDuckGo
Most Visited Pale Moon Pale Moon forum F.A.Q. Release notes
pfSense.home.arpa - Status: ...
Connecting...
pfSense Netgate View license
Done
Menu
pfSense.home.arpa - Stat

```
✕  Jan 5 09:14:48  LAN  Default deny rule IPv4 (1000000104)  192.168.1.1:443     192.168.1.100:51428  TCP:RPA
✕  Jan 5 11:01:18  WAN  USER_RULE (1672916416)              10.0.2.15:26949     1.1.1.1:443          TCP:S
✕  Jan 5 11:01:18  WAN  USER_RULE (1672916416)              10.0.2.15:45393     1.1.1.1:443          TCP:S
✕  Jan 5 11:01:19  WAN  USER_RULE (1672916416)              10.0.2.15:7057      1.1.1.1:443          TCP:S
✕  Jan 5 11:01:19  WAN  USER_RULE (1672916416)              10.0.2.15:61853     1.1.1.1:443          TCP:S
✕  Jan 5 11:01:21  WAN  USER_RULE (1672916416)              10.0.2.15:56961     1.1.1.1:443          TCP:S
✕  Jan 5 11:01:21  WAN  USER_RULE (1672916416)              10.0.2.15:22688     1.1.1.1:443          TCP:S
✕  Jan 5 11:01:25  WAN  USER_RULE (1672916416)              10.0.2.15:56973     1.1.1.1:443          TCP:S
✕  Jan 5 11:01:25  WAN  USER_RULE (1672916416)              10.0.2.15:41478     1.1.1.1:443          TCP:S
```

» pfSense keeps a log of its traffic, so you can see what it's doing behind the scenes.


pfSense.home.arpa - Firewall: Rules: Floating: Edit - Pale Moon
File Edit View History Bookmarks Tools Help
https://192.168.1.1/firewall_rules_edit.php?id=0
DuckDuckGo
Most Visited Pale Moon Pale Moon forum F.A.Q. Release notes
pfSense.home.arpa - Firewal...
pfsense COMMUNITY EDITION
System Interfaces Firewall Services VPN Status Diagnostics Help
pfSense Netgate View license
Done
Menu
pfSense.home.arpa - Firew

Firewall / Rules / Floating / Edit

Edit Firewall Rule

Action Block
Choose what to do with packets that match the criteria specified below.
Hint: the difference between block and reject is that with reject, a packet (TCP RST or ICMP port unreachable for UDP) is returned to the sender, whereas with block the packet is dropped silently. In either case, the original packet is discarded.

Disabled ☐ Disable this rule
Set this option to disable this rule without removing it from the list.

Quick ☐ Apply the action immediately on match.
Set this option to apply this action to traffic that matches this rule immediately.

Interface WAN
LAN
Choose the interface(s) for this rule.

Direction any

Address Family IPv4
Select the Internet Protocol version this rule applies to.

Protocol TCP
Choose which IP protocol this rule should match.

Source

Source ☐ Invert match any Source Address /

Display Advanced
The **Source Port Range** for a connection is typically random and almost never equal to the destination port. In most cases this setting must remain at its default value, **any**.

Destination

Destination ☐ Invert match Single host or alias 1.1.1.1 /

Destination Port Range any From Custom any To Custom
Specify the destination port or port range for this rule. The "To" field may be left empty if only filtering a single port.

Extra Options

Log ☑ Log packets that are handled by this rule
Hint: the firewall has limited local log space. Don't turn on logging for everything. If doing a lot of logging, consider using a remote syslog server (see the Status: System Logs: Settings page).

Description
A description may be entered here for administrative reference. A maximum of 52 characters will be used in the ruleset and displayed in the firewall log.

Advanced Options Display Advanced

Rule Information

Tracking ID 1672916416
Created 1/5/23 11:00:16 by admin@192.168.1.100 (Local Database)
Updated 1/5/23 11:01:06 by admin@192.168.1.100 (Local Database)

Save

» Edit firewall rules to set what traffic will and won't be allowed through.

» Once you've configured your computers to connect through pfSense, you can apply rules to their internet access, as well as incoming requests from external servers. For example, to block access to a specific host, pull down the Firewall menu from the top and click Rules, followed by Floating ("floating" rules can apply to either the WAN or LAN interface). Click add to create a new rule, then set the Action menu to Block and tick the box beside "Apply the action immediately on match".

» Now, in the Destination block, select "Single host or alias" from the dropdown, and in the field to the right type the IP address of the server you want to block. In the screenshot below left, we're using the Cloudflare DNS service as an example since it's an easy address to remember, but this is just for testing. When you return to the previous screen, click Apply to enable the rule.

» If you now try to visit 1.1.1.1 from any machine for which pfSense is the DHCP server, you should fail to reach the destination (see image).

6 ADVANCED CONFIGURATION

Visit docs.netgate.com/pfsense/en/latest to learn what else pfSense can do, including notification settings, advanced optimization options, IPv6 settings, and how to handle things such as VPNs and VLANs.

LAB NOTES

GUY COCKER, EDITOR-IN-CHIEF

Intel: Budget Savior?

Is Intel the answer to our sub-$1,000 Budget Build problem?

IN THE COMMENTS SECTION of *Maximum PC* (see pages 94-95), the most hotly contested issue of the last few months has been our Budget Builds in the Blueprints section (page 96). These builds started out costing less than $1,000, but then over the last year, they crept upwards as graphics card prices commanded ever-greater premiums. We got some feedback on this that then sparked a debate about what a budget build should be in 2023—some readers suggested we drop the GPUs and make them work-machines only, while others said it was important that they were capable of playing games at 1080p. We decided to go with the latter option, and Sam, who curates the build each month, got the prices back down to three figures by using older GPUs which had become cheaper over time.

This month's cover build has me thinking that we might have found close to a perfect budget build, using a GPU from a company I never expected. But as Sam has shown us on page 16, the budget-friendly pairing of the Core i5-13400 CPU and A750 Arc GPU offers significant current-gen power in a case that has loads of room to grow, and all at a price that's comfortably within three figures.

I still think that for the majority of our readers, AMD and Nvidia are the ways to go when it comes to GPUs. Intel's Arc series gets the job done for those on a budget, but they're not the cards for ray-traced, high-resolution gaming. But as Jarred's feature in our April 2023 issue highlighted, Intel has been putting in the work to improve its graphic card drivers to deliver results, while as his feature in this issue on page 50 shows, the video encoding smarts of these cards make them excellent choices for live streamers and video editors.

Sam's sub-$1,000 build this issue has impressed.

I also personally met Intel recently, and after a rocky start, there seems to be a growing feeling of confidence that they're on the right track when it comes to capturing the budget market. With AMD and Nvidia increasingly obsessed with the $899+ market, there will be plenty of people who will welcome Intel's sub-$349 cards with open arms.

SAM LEWIS

Staff Writer

Over my time at *Maximum PC*, I've been able to test my fair share of headphones and headsets, but it's the most recent pair from Audeze that I feel might be the best of the bunch. I managed to get my eager hands on the Maxwell gaming headset to review, and while I've had this sample I've not been able to put them down. Whether that be for gaming, listening to music (which honestly feels like 95 percent of my life), or watching videos, I've got plenty of use from the Maxwell. The build quality and rich, punchy, and detailed audio has resulted in me being fully immersed in these headphones.

I put these on in the evenings after work, and the next thing you know, three hours have gone by. That's when you can really tell how great a pair of headphones are. Granted, at $300 they're on the pricy side for a gaming headset, but they ofer some great features, such as being able to hear a player breathing from the other side of the map, while also taking you to another world when listening to your favorite tunes. It's almost like listening to your music for the first time again.

The issue is now I'm certainly going to want to buy a pair for myself, and then I'll probably go AFK for a few months at a time while I hibernate in audio bliss. For the record (and my editor), the last statement is a slight exaggeration, but you catch my drift.

Finally, this is OLED and HDR done right on the desktop.

Editor's Pick: Philips Evnia 34M2C8600

It's here—an OLED PC monitor that truly works!

I GIVE YOU the Philips Evnia 34M2C8600. Funnily enough, its core components and specs aren't novel. It uses the same 34-inch QD-OLED panel from Samsung that we've already seen in the Alienware AW3423DW, and will be used by Samsung itself, MSI, and others.

However, Philips has given its monitor a low-tech twist. This is a 34-inch ultra-wide panel with a 3,440 by 1,440 native resolution. It's ideal for gaming, but arguably sub-optimal for everyday tasks.

The pixel density clocks in at a pedestrian 110DPI. That's not enough for nice, crispy fonts, nor is the resolution sufficient for 4K content. This is still a decent display, it's just at this price point of around $1,200 there are better options.

Anyway, in most regards this monitor is a dead ringer for the Alienware. You get the same uber-immersive 21:9 aspect ratio, plus a 1800R curve. As for brightness, the Evnia's 1000 nit peak in a three percent window and 250 nit full-screen brightness are, again, identical to the Alienware, as is the 0.1ms response and 175Hz refresh.

So what sets the two apart? The Philips lacks the Alienware's Nvidia G-Sync module while adding USB-C with 90W of power delivery. But the feature that really gaps the Alienware is the Philips' glossy screen coating. It makes all the difference.

On the Alienware, there's a matte coating that robs the display of impact. It reduces the sense of contrast and prevents black tones from being inky. Instead, this Philips monitor absolutely sizzles.

It looks best in HDR True Black mode, which limits peak brightness to 400 nits. HDR highlights still pop thanks to the contrast with the perfect black levels. In HDR True Black mode, the colors are nicely calibrated and there's almost no variation in brightness due to the automatic brightness limiter (or ABL) that so blights PC monitors using LG OLED panels.

Even better, SDR content also looks great in HDR True Black mode, so you don't have to mess around changing modes depending on whether you're on the web or playing an HDR game. You can just leave your PC in HDR True Black mode all the time, and everything looks great.

It's a relief to find a high-end monitor using the latest display tech. Meanwhile, OLED monitors using LG panel tech, like the Corsair Flex, are hopeless as all-round PC tools thanks to poor full-screen brightness and ABL algorithms that have the brightness all over the place. The Alienware AW3423DW got close, but lacked the visual drama to justify the promise of OLED technology and its price.

But something as simple as the glossy coating on this Philips panel has fixed that. The 3,440 by 1,440 resolution prevents this from being a peak all-round monitor. Unfortunately, this generation of OLED PC monitors all have panel tech derived from OLED TV sets, so the pixel density is only as good as the smallest 4K OLED TVs.

There's one detail I haven't mentioned: OLED burn-in. It's hard to say how well these new OLED monitors will fare in that regard. Philips covers the screen for three years, so you know you're covered for that long. But of all PC components, monitors tend to be long-term investments.

I'd be more comfortable with five year cover. If I got five full years of use out of this thing, I'd accept if it then began to wear out or needed replacing. But that final caveat aside, this is as good as it currently gets for PC gaming. **–JEREMY LAIRD**

$1,200, www.philips.com

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88 Elgato Stream Deck +

89 SteelSeries Stratus Duo

Avast One
Everything looks good!
London, UK
17 apps

90 Resident Evil 4 Remake

92 AVG Free vs Avast One Essential

AMD
RYZEN
AMD Ryzen 9 7950X3D
100-000000908
BS 2253PGY
9KR1369M30004
MADE IN MALAYSIA
© 2022 AMD

The Ryzen 9 7950X3D offers explosive gaming performance, but at a steep financial cost.

AMD Ryzen 9 7950X3D

The best gaming CPU, but not quite the one chip to do it all

AMD'S ATTEMPT TO create the ultimate gaming and productivity chip has almost worked with the Ryzen 9 7950X3D. It has once again proven the power of the 3D V-cache technology when it comes to squeezing higher gaming performance out of its processors, and has married that to an asymmetrical chiplet layout that can deliver the goods in productivity. The price and small gains in 4K games are the only things spoiling the party.

Once again, AMD has bonded an extra 64MB of L3 cache to an eight-core chiplet (this time a Zen 4 one) to double its last-level cache, for a total of 128MB. It has to limit the clock speed of that chiplet, too, as it's important that it's the same height as a standard Ryzen 7000-series CPU.

That's challenging, because this time there are two chiplets in the package. But AMD has taken the smart move of limiting the 3D V-cache to just one of them, leaving the second in exactly the same state as it is on the standard Ryzen 9 7950X. It's cheaper to do, but also means that it can have one side of the CPU with eight Zen 4 cores that can operate best for applications that benefit most from low latency memory, and another eight cores that will run at a peak clock speed frequency the others can't manage.

To that end, AMD's got its 3D V-cache Performance Optimizer and PPM Provisioning File drivers in its latest chipset software package. The first works in real time to modify what cores Windows can see, highlighting either the standard die or the 3D V-cache chiplet, depending on the workload it detects.

The final thing to note about the newer Ryzen 7000-series chips is their lower TDP. They're rated at 120W, as opposed to 170W, and are more efficient in operation than the Zen 4 vanguard. The gaming lead is even more impressive when you look at performance per watt and the heat it generates. Taking our standard *Far Cry 6* benchmark for frame rates per watt, the 7950X3D is 86 percent more efficient than the previous top AMD processor, and 54 percent more efficient than the 13900K.

Its gaming prowess is highlighted at lower resolutions, but it's not just at 1080p and below where you'll see the difference. Even strapped to an Nvidia RTX 4090, the Ryzen 9 7950X3D is able to encourage higher frame rates from the system as a whole compared to either AMD or Intel rivals at top 1440p settings.

At 4K, however, the upper echelons of gaming where such a high-end rig will largely reside, there is little difference between this new AMD chip and Intel's i9 13900K. That's at a point where the onus is almost entirely on the graphics card to deliver. But it's enough to know that of all the CPUs around, this is the one most likely to deliver the best performance from an expensive graphics card.

As a high-end gaming processor, it's a win in both raw performance and efficiency. The 7950X3D doesn't consume anywhere near the same amount of power as its non-cached Zen 4 7950X sibling, or the super-thirsty Intel Raptor Lake chips, and smashes both it and the Intel Core i9 13900K when it comes to frames rate per watt.

But the end result isn't quite the AMD line of "one processor can do it all." The Ryzen 9 7950X3D is an expensive gaming processor that falls just a little short of its now-cheaper 16-core forebear when it comes to specifically CPU-intensive tasks, even if it can demonstrably top it in the gaming frame rate stakes.

In the end, the AMD Ryzen 9 7950X3D is just about the best gaming CPU on the market, even if that moniker retains some questionable real-world relevance. There are two cheaper X3D chips coming from AMD, likely with the same efficiency increase, but for a lower price. That makes this $699 processor of maybe rather niche interest, with slightly compromised raw CPU performance outside of games. **–DAVE JAMES**

VERDICT

8

AMD Ryzen 9 7950X3D

+ RYZEN HIGH Tangible gaming performance lead; remarkable efficiency.

− RYZEN DAMP Lower raw CPU performance; costly compared to the competition...and AMD's other X3D chips.

$699, www.amd.com

BENCHMARKS

	App Ryzen 9 7950X	Intel Core i9-13900K	Ryzen 9 7950X3D
Cinebench R23 Single Core	2008	**2201**	2031
Cinebench R23 Multi Core	38,028	**38,677**	35,715
PCMark 10 Express	**7,572**	7,310	7,190
Max CPU Temperature (degrees C)	90	94	**80**
Far Cry 6 (1080p, High, fps)	154	175	**183**
F1 2021 (1080p, Ultra, fps)	205	192	**218**
Gaming Performance per Watt (Far Cry 6, 1080p)	1.54	1.86	**2.86**

Best scores are in bold. Our AMD test bench consists of an ASRock X670E Taichi motherboard and G.Skill Trident Z5 Neo DDR5-6000 CL30 2x 16GB RAM. Intel test bench was an Asus ROG Z690 Hero and G.Skill Trident Z5 RGB DDR5-5600 CL36 2x 16GB. Gaming tests were done with an Nvidia RTX 4090 FE GPU.

SPECIFICATIONS

Cores	16
Threads	32
Socket	AMD AM5
CCD lithography	TSMC 5nm
CCD die size	70mm²
CCD transistor count	6.5 billion
IOD lithography	TSMC 6nm
IOD die size	122mm²
IOD transistor count	3.4 billion
Max boost clock	5.7GHz
Base clock	4.2GHz
L2 cache	16MB
L3 cache	128MB (inc. 64MB L3D)
Memory support	DDR5-5200 (non-OC)
TDP	120W

ASUS ROG Zephyrus M16 2023

Is it as good as it looks on paper?

IT'S CRAZY HOW a GPU as powerful as the RTX 4090 can be condensed to fit within a laptop, let alone alongside the rest of the components. So when we got the chance to take a look at an all-new ASUS laptop featuring an RTX 4090, we were more than excited. The ROG Zephyrus M16 from last year was an impressive device, so this revised 2023 model with an Intel i9-13900H and an RTX 4090 inside should be a recipe for success, right?

The design hasn't changed much over last year's model. The chassis is matte black aluminum and magnesium, making it feel tough and rugged. The hinge feels sturdy, too, and there's no screen wobble. The design changes drastically when we take a look at the lid, though. ASUS has introduced an LED lighting panel, a.k.a. AniMe Matrix. It's an attention-grabbing feature, but falls more into the gimmick category. You can add your own animations, have it react to music, or add text. However. you can't see it while you're using the laptop, so it's a little pointless. Saying that, you can also disable it.

Opening it up, we're greeted with a large 16" 16:10 ratio panel. It has thin bezels, with a 92 percent screen-to-body ratio. Despite the subjective ASUS typeface, we love the feel of the keyboard. The keys have deep travel, yet maintain responsive feedback. They're also backlit, and the glow can be adjusted in the ASUS Armoury Crate software. The trackpad is very responsive, with a tactile feel to the buttons. Above the screen is a Full-HD 1080p camera. It's adequate for meetings, especially with the built-in microphone, as that does a great job of capturing your voice clearly.

Back to the screen, its aforementioned 16:10 ratio gives you slightly more vertical real estate. ASUS calls this the Nebula HDR Mini-LED display, and it's nothing short of stunning. It's incredibly rich in color thanks to its 100 percent DCI-P3 color coverage, and very bright at 1,100 nits from the Mini-LED technology. It has been factory calibrated to meet Pantone color palette standards, making it great for digital artists and video editors. Not only that, it's buttery smooth, with a refresh rate of 240Hz, and a response time of 3ms. But can we get the most out of it with what's beneath?

Yes, but at a cost. The mastermind behind this system is Intel's i9-13900H packing 14 cores (6 for performance and 8 for efficiency), 20 threads, and clock speeds of 2.6GHz. Pair this with an Nvidia RTX 4090 GPU, and you're in for a world of fun, right? Well, not quite, although our 4K ultra benchmarking results are impressive, especially on a laptop, when we compared them to the RTX 4080 machine we built in our February 2023 issue, it was just slightly behind. The 4090 inside of this machine has been limited to 120W in its turbo mode, so performance is capped here, making the cheaper RTX 4080 variant of the M16 better value when it comes to bang for buck.

All this power comes at a cost, and not just the $3,499 price tag. Its battery life isn't great, but this isn't shocking—the GPU requires a lot of power, and we can't recommend using this to game on unless it's plugged into an outlet. So where does this leave us? It's an impressive machine, but when you can build a better-performing PC for around $675 less (our RTX 4080 February 2023 cover build), you must really value portability to go with this laptop option. Sure, ASUS' offering will provide you with the same great gaming experience and eye-popping visuals, but it's an expensive way to do so. **–SAM LEWIS**

BENCHMARKS

	ZERO-POINT	
Cinebench R23 Single-Core (Index)	1,962	2,030 (3%)
Cinebench R23 Multi-Core (Index)	18,502	18,537 (0%)
CrystalDisk QD32 Sequential Read (MB/s)	7,427	7,061 (-5%)
CrystalDisk QD32 Sequential Write (MB/s)	6,649	5,195 (-22%)
3DMark Fire Strike Extreme (Index)	31,648	17,749 (-44%)
Cyberpunk 2077 (fps)	73	72 (-1%)
Cyberpunk 2077 RTX (fps)	49	31 (-37%)
Metro Exodus (fps)	91	75 (-18%)
Metro Exodus RTX (fps)	63	38 (-40%)
Total War: Three Kingdoms (fps)	81	81 (0%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of the RTX 4080 Gaming Machine from our February 2023 issue, featuring an AMD Ryzen 7 7700X, Nvidia Founders Edition GeForce RTX 4080 16GB, Asus ROG STRIX B650-A Gaming Wi-Fi, 32GB (2x16) of Corsair Vengeance DDR5-4800, and 1TB SK Hynix Platinum P41 PCIe 4.0 M.2 SSD. All games tested at 4K 'Ultra' graphics presets with DLSS and V-sync turned off and XMP for RAM speed turned on. No manual CPU overclocking.

VERDICT

8

ASUS ROG Zephyrus M16 2023

+ ALL THE GEAR Silky 240Hz refresh rate; gorgeous panel; lightning CPU/GPU combo.

− NO IDEA? Poor battery life; unsmooth edges; very expensive; gimmicky lid lighting.

$3,499, www.asus.com

SPECIFICATIONS

CPU	Intel i9-13900H @2.60GHz
Graphics	NVIDIA GeForce RTX 4090 16GB GDDR6
RAM	16GB DDR5 @4800Mhz
Screen	16" QHD (2560 x 1600) Nebula HDR Mini-LED @ 240 Hz
Storage	2TB M.2 PCIe 4.0 SSD
Ports	1x HDMI 2.0b, 1x Thunderbolt 4 support DisplayPort, 1x USB 3.2 Gen 2 Type-C, 2x USB 3.2 Gen 1 Type-A, 1x RJ45 zLAN port, 1x 3.5mm Combo Audio Jack.
Weight	5.07 lbs
Size	0.8 x 9.7 x 13.9 inches

It's a good machine, but not easy to justify for the price.

Going all-AMD definitely has its advantages.

Alienware M17 R5

Ryzen 6900HX meets Radeon RX 6850M XT

WE'RE NOW at a place where it's truly a competition in the laptop space. Instead of Intel and Nvidia ruling the gaming scene, AMD is making some serious noise and OEMs are starting to dance to its beat.

Enter the Alienware m17 R5. Boasting an AMD Ryzen 9 6900HX processor and a Radeon RX 6850 XT GPU, the laptop is not to be trifled with. Thanks to AMD Advantage Suite, this system is optimized to ensure that you're getting the best performance out of it. You also get Cherry MX keys, a stunning 4K display, great speakers, and a slick design to boot.

Our test configuration featured the 3.3GHz AMD Ryzen 9 6900HX processor with 32GB of RAM, 1TB PCIe NVMe M.2 SSD, AMD Radeon RX 6850 XT GPU with 12GB of VRAM, and a 3,840 x 2,160 display with a 120Hz refresh rate and 3ms response rate. In other words, it's a powerful machine.

The laptop also follows Dell's Legend 2.0 design language, with a grayish black finish, numerous RGB elements around the alien logos, and onyx black vent at the rear. It looks nice, but this isn't the most portable 17-inch laptop at 15.6 x 11.8 x 0.9-inch and 7.3 pounds. If that's important for you, look for the thinner and lighter MSI Vector GP76, Razer Blade 17, or Asus ROG Zephyrus Duo 16.

There are ports on the back and sides, including three USB-A 3.2 Gen 1 ports, a USB Type-C 3.2 Gen 2 port, HDMI 2.1, an expandable Gigabit Ethernet port, and a headset jack. There's also a DC-in port for the 240W charger, which is bulky and heavy, and I couldn't get the laptop to charge using USB-C. I'd have liked to see more USB-C ports, but this is where you pay the price for going AMD—Intel laptops tend to have more and faster USB-C ports.

The 17.3-inch 4K display is simply stunning. Games such as *Cyberpunk 2077* look tailor-made for it, with the neon skyline of Night City glittering almost as brightly as the stars in its sky. FreeSync Premium prevents screen tearing, with low frame rate compensation (LFC) also keeping things smooth. Colors looked good and we loved the 436 nit brightness, but the measurable color reproduction was less impressive, only measuring 76.2 percent on the DCI-P3 color gamut. It's also Dolby Vision enabled if movie watching on a laptop is your thing.

The unique feature of this laptop is its all-AMD design, which the company dubs AMD Advantage. It basically means an AI system runs in the background to keep it functioning optimally, offering max performance when needed in games and productivity (what AMD calls SmartShift Max), and battery optimization when you're not (SmartShift Eco). You can monitor this in real time with AMD Software: Adrenalin Edition. There's also AMD Smart Access Memory, which allows the Ryzen CPU to access the 12GB of GPU memory over a fast PCI Express 4.0 link, which helps to eliminate bottlenecks.

This results in some impressive performance in games, with 80+ frames per second at 1080p Ultra in the likes of *Assassin's Creed Valhalla*, *Metro: Exodus*, and *Far Cry New Dawn*. Sadly, crank things up to 4K, and those frame rates go down to the 40+ fps level. This means that as nice as that 4K screen may be, you'd be better off saving money and going for the 1080p option unless your work or video consumption demands it.

It managed six hours and seven minutes on our battery test, which consists of continuous web surfing over Wi-Fi at 150 nits. The speakers also sounded better than on most laptops, with Dolby Atmos support, plus Performance audio settings, which help players locate that footsteps. Sadly, the 720p/30fps webcam left a lot to be desired.

At around $2,300 in our review configuration, and $2,000 for the 1080p version, this Alienware is good value for a desktop replacement. It's a premium product that makes the most of its all-AMD configuration. While the urge to go for an Nvidia 40-series may be strong, AMD shows it's still worth considering, especially with the price of those machines being so high. –**SHERRI L. SMITH**

BENCHMARKS

	ZERO-POINT	
Geekbench 5 Single Core	1,318	1,522 (15%)
Geekbench 5 Multi Core	8,051	9,914 (23%)
File Transfer Test (MBps)	1,306	1,767 (35%)
Shadow of the Tomb Raider (fps)	105	99 (-6%)
Grand Theft Auto V (fps)	125	104 (-17%)
Far Cry New Dawn (fps)	98	89 (-9%)
Borderlands 3 (fps)	100	112 (12%)
Red Dead Redemption 2 (Medium) (fps)	82	76 (-7%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of the Alienware m17 R4, featuring an Intel Core i9-10980HK, Nvidia GeForce RTX 3080, 32GB DDR4 RAM and 512GB + 2TB (2 x 1TB RAID 0) SSD. Games were tested at 1080p on highest settings unless stated.

VERDICT

7

Alienware M17 R5

ADVANTAGES Sleek design; great performance; comfortable keyboard; long battery life; clear audio.

DRAWBACKS 720p webcam; expensive.

$2,300, www.alienware.com

SPECIFICATIONS

CPU	AMD Ryzen 9 6900HX
GPU	AMD Radeon RX 6850 XT 12GB/ AMD Radeon Graphics
RAM	32GB DDR5
Storage	1TB PCIe NVMe M.2 SSD
Display	17.3-inch, 4K
Webcam	720p
Battery	97 Wh
Wireless	Wi-Fi 6, Bluetooth 5.2
Ports	3 x Type-A USB 3.2 Gen 1 Port, 1 x Type-C Port, Headset, HDMI 2.1, Ethernet, Power-adapter
Keyboard	CherryMX low-profile mechanical
Size	15.64 x 11.76 x 1.05 inches
Weight	7.3 pounds

ASRock Phantom PG34WQ15R2B

Proof that a great gaming experience remains affordable

THANKS TO a new breed of OLED panels, it's easy to unload well over $1,000 on a 34-inch ultrawide gaming monitor. Alienware, Samsung, MSI, and Philips will be happy to let you scratch that itch.

But those ultrawide OLEDs are all 3,440 by 1,440 pixel monitors. For over $1,000? Really? Enter the ASRock Phantom PG34WQ15R2B. It too is a curved 34-inch ultrawide gaming panel with 3,440 by 1,440 pixels. With a maximum refresh of 165Hz, it's likewise within 10Hz of the best of those megabucks OLED monitors. And yet it's yours for a piffling $369.

Of course, there's no OLED tech. You don't even get an IPS panel. Instead, it's the cheaper VA variety. That's not always good news for gaming. There's a reason why IPS is more popular with gamers, and that's response: IPS is quicker. Well, usually. Samsung has managed to squeeze IPS-rivalling pixel response out of its VA panels, but that is the exception.

ASRock claims 1ms response for the Phantom PG34WQ15R2B. However, that's by the MPRT metric, not the more demanding gray-to-gray. Whatever the response times, VA does have benefits. You get better inherent contrast, in this case 1,000 to one, which is three times better than most IPS monitors. That makes for better HDR performance without the need to resort to an expensive, buggy mini-LED backlight.

ASRock rates this monitor at 550 nits peak brightness, and the panel has HDR 400 certification, plus claimed 91 percent coverage of the DCI-P3 gamut. As for connectivity, there's a single DisplayPort 1.4 input and a pair of HDMI 2.0 ports. Only DisplayPort supports the full 165Hz refresh; the HDMI ports are limited to 100Hz. While there is no USB, integrated high-gain Wi-Fi antenna is present.

In standard SDR mode, the ASRock won't blow your visual socks off. But the colors are reasonably accurate and the contrasty VA panel pleasing. However, in HDR mode, good things happen. If you tweak the SDR brightness settings, you can improve the SDR experience in terms of colors, brightness, and calibration.

That means you can leave this in HDR mode, instead of switching back and forth. The actual HDR experience, meanwhile, is as good as you can expect for a DisplayHDR 400 panel with no local dimming. HDR-capable games do actually look more dynamic in HDR mode.

Speed wise, it is behind the best IPS panels, but only a touch. More importantly, the 165Hz refresh makes for low latency, and the impact of a 34-inch ultrawide panel is as immersive as ever. The 3,440 by 1,440 pixel native resolution is likewise a good compromise between visual detail and frame rates.

All of this makes it a very appealing gaming panel. The 34-inch ultrawide thing is great, the image quality is good, and the speed is fast enough. You could spend three times as much on the OLED alternative, but you wouldn't get three times the experience. **–JEREMY LAIRD**

VERDICT

8

ASRock Phantom PG34WQ15R2B

+ BY GRABTHAR'S HAMMER Contrasty VA panel; fab 34-inch ultrawide form factor.

− NOT A SAVINGS Limited HDR performance; not quite as fast as an IPS panel.

$369, www.asrock.com

SPECIFICATIONS

Screen size	34-inch
Panel type	VA
Resolution	3,440 x 1,440
Brightness	550 nits
Contrast	3,000:1
Response time	1ms MPRT
Refresh rate	165Hz
Colour coverage	91% DCI-P3
HDR support	DisplayHDR 400
Adaptive sync	FreeSync Premium, G-Sync Compatible
Connectivity	DisplayPort 1.4 x1, HDMI 2.0 x2

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PHANTOM GAMING

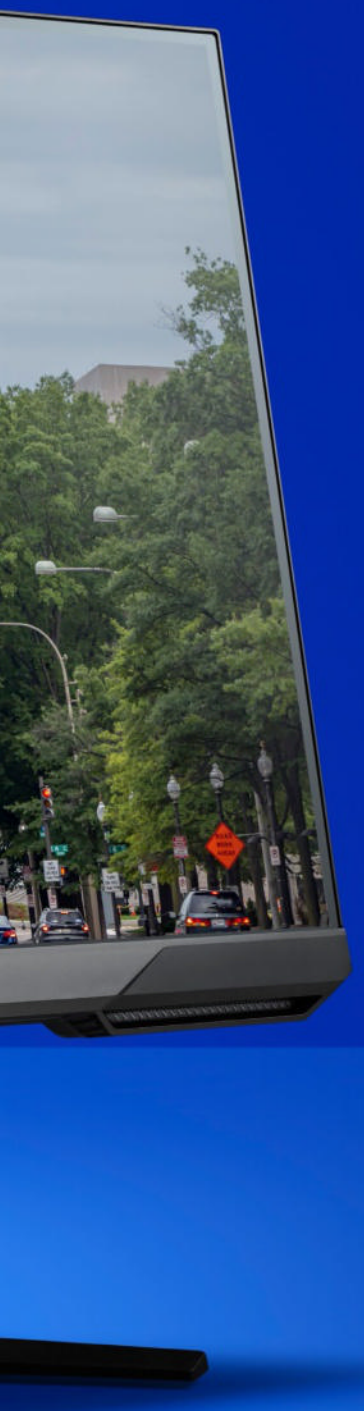
ASRock's new gaming monitor is one third of the price of similarly proportioned OLED panels.

NVIDIA G-SYNC
SAMSUNG

Samsung makes some nice-looking monitors, and the Odyssey G70B is another premium offering.

Samsung Odyssey G70B (32-inch)

Great features, but the price and competition spoil the fun



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WHEN WE'VE COVERED Samsung Odyssey monitors of late, they've tended to be on the pricier side, such as the Neo G8 in March ($1,300), or the Ark in January ($3,500). This Odyssey G70B isn't going to feature on any budget buy lists, but at $699, it's more affordable than those screens. At first glance it has a veritable wishlist of features for gaming fans, including 4K, 144Hz, 1ms response time, IPS panel, and G-SYNC support. Add smart features for streaming, and you have a very appealing proposition.

AI frame generation and upscaling tech has come a long way, but 4K displays are still the domain of high-end GPU owners. If you are in a position of owning a beefy Nvidia or AMD graphics card, though, 32 inches is the sweet spot in terms of size, which this G70B sits at. You get plenty of real estate to enjoy cinematic titles such as *Dead Space*, as well as run multiple windows when working.

We particularly like the finish on the screen of the G70B, which is matte on the spec sheet, but feels somewhere in between matte and glossy. Our main disappointment is the screen's 400 nits of brightness, which is average for IPS screens, but no longer at this price point. Late last year, LG released its 32GQ950-B, which has a similar price and specifications, but offers higher brightness for SDR content, plus more dimming zones for better HDR performance. Given that the LG also offers a higher 160Hz refresh rate, it's difficult to recommend the Samsung if what you value most is picture quality.

Where the Samsung does win points back is in its feature set. As a content consumption device, Samsung has every other monitor manufacturer beat. The key is Tizen OS, the interface it uses on its TVs. This means it has all the video apps you'd expect, streaming from Nvidia and Xbox, plus the ability to mirror content via Airplay and Bluetooth. Yes, a lot of these apps and features will be on the PC or games console you'll have connected to it, but the convenience of having it on a central hub that can be operated via the included remote is a boon.

Connectivity is also good, with two HDMI 2.1 ports that support all display outputs from the latest consoles, plus DisplayPort 1.4 for your PC. There are a couple of USB-A ports, but we'd also liked to have seen USB-C connectivity on a modern monitor at this price.

The G70B, then, is a monitor that offers all the things you'd want from a 4K monitor, and distinguishes itself with some fantastic smart features that aren't on any other monitor. Sadly though, it arrives just after the similar LG 32GQ950-B, which lacks a lot of those features, but is the better option when it comes to SDR and HDR performance. Yes, LG's monitor lacks G-SYNC certification (though supports it), but if you're a picture purist looking for a sub-$800 monitor, that's the one to go for.

If you're not comparing the two, or you see the Samsung Odyssey G70B on offer, then it's still worth checking out, with good picture quality, great connectivity, and a unique smart hub. **–GUY COCKER**

VERDICT
6

Samsung Odyssey G70B (32-inch)

➕ **SMART** Smart features; plenty of ports; G-SYNC support.

➖ **STUPID** Low brightness; middling HDR performance; average refresh rate.

$699, www.samsung.com

SPECIFICATIONS

Panel type	IPS
Panel Size	32 inch
Aspect ratio	16:9
Response time	1 ms
Color Gamut	95% DCI
Brightness	400 nits
HDR	HDR 400
Contrast ratio	1,000:1
Viewing angle	178º
Display colors	1 billion
Adaptive Sync	AMD FreeSync Premium Pro, G-SYNC
Maximum resolution	3,840 x 2,160 @ 144 Hz
Ports	HDMI 2.1 x 2, DisplayPort 1.4 x 1, USB-A x 2, Ethernet, Audio
Wireless	WiFi5, Bluetooth 5.2
Weight	18.3 lbs inc. stand
Set Dimension	28.12 x 23.72 x 12.25 inches (with stand)

XGIMI
harman/kardon
4K

With a screen of up to 200-inches, the XGIMI Horizon Pro 4K offers a truly cinematic experience.

XGIMI Horizon Pro 4K Projector

The best alternative to a TV?

IF YOU'RE PAYING just shy of $2,000 for a projector, then it's probably desirable that it meets certain criteria. The chances are you're buying one to increase the size of your screen so, of course, it has to have a large projection size. The quality also has to impress, otherwise, the novelty soon wears thin, and it has to be easy to use. If these three criteria are met, then you should be halfway there to an immersive cinema experience that improves upon a conventional TV.

Ideally, your new projector should also have all the functionality of a smart TV with alternative connectivity options for a game console or a PC, for example. XGIMI is no stranger to the world of projectors and this Horizon Pro 4K model is one of the top offerings in its range. So, can this media masterpiece conquer all and be your next projector?

We've tested the smaller sibling, the Halo+ (see May 2022 issue), and ended up singing its praises. It boasted a tremendous build quality with a premium edge to its design and that same ethos has carried over to the larger Pro model. It's a handsome-looking device that looks more like a high-end speaker than a projector. It features a cubic style, gunmetal grey outer layer, and a matte black upper, meaning it could easily fit into most environments without looking out of place—and that's not something you can say about all projectors. The whole surface of the Horizon Pro has a grilled texture that does a great job of hiding the fans and speakers too. On the front, you get a larger lens than the Halo+ and also a keystone and autofocus lens.

As with other XGIMI projectors, the Horizon Pro offers great keystone and autofocusing software capabilities. This eliminates one of the most common problems when using a projector, the setup process. The auto-keystone correction setting means you can offset your projector and still get a straight and clean image on your wall. You can further fine-tune this with the manual adjustment option. There are also choices for auto-obstacle avoidance, auto-screen alignment, auto-keystone upon motion or startup, and an image zoom function. All of these allow the user to get the perfect display for their setup.

This projector uses the Android TV OS, meaning that the UI is fluid and there are plenty of options to customize your experience without having to connect any other external devices to the Horizon Pro. There are plenty of services available out of the box, including built-in Chromecast, Google Play Store, and Google Assistant, so you can get most of what you need here. However, if you want to connect externally, there are two HDMI ports, two USB ports, and an Optical and 3.5mm port so you can connect a different speaker setup. Saying that, the built-in Harmon Kardon speakers do a perfectly good job of delivering a warm and loud solution for a typical living room environment, much like a decent, high-end TV would.

Although it already ticks lots of boxes, the most important part of this Horizon Pro is how it looks on the big screen. When you boot this device up for the first time, it's easy to get caught up in the nostalgia of past trips to the cinema. As you glance over to your wall, your old 55-inch TV screen now feels more like watching a film on your smartphone in dimensions than this new mammoth display taking up the whole wall. Having taken it home to test it out, we fear it will be difficult to go back to a normal TV.

Not only can this projector cast a display of up to 200-inches in size, it does so with impressive picture quality, boasting a 4K resolution that holds up well, right up to that 200-inch maximum. The detail is crisp at all times, especially with the ability to autofocus straight from the included remote to quickly get your picture correct. In the settings, you can choose between many presets and alter your color setup. We would recommend enabling the motion compensation—we had it set to 'strong' and it did a good job of smoothing out the image, considering the 60Hz refresh rate. Thanks to a rating of 2,200 ANSI lumens, brightness is good enough for all-day viewing, which can be an issue with some projectors. Great color accuracy and contrast make this display a joy to use and experience. While the 1080p Full HD models provide admirable image quality, this 4K model takes things up a gear and in terms of longevity, is the better option.

The kicker here is that it's an expensive product. Sure, it provides stunning visuals and great brightness and has an abundance of features to make the projector process easy and enjoyable but it will empty your wallet. However, if you're looking for a projector that can replace your TV, you won't go wrong with the XGIMI Horizon Pro 4K. **–SAM LEWIS**

VERDICT
9

XGIMI Horizon Pro 4K

+ CINEMATIC MASTERPIECE Fantastic premium feel; gorgeous picture quality; Android TV built-in; rich sound stage.

− BOX-OFFICE FLOP 60Hz max refresh rate; wallet damaging.

$1,899, us.xgimi.com

SPECIFICATIONS

Projector type	DLP
Native resolution	4K 3840 x 2160
Refresh rate	60Hz
Brightness	2,200 ANSI Lumens
Projection size	up to 200 inches
Lamp life	30,000 hours
Connectivity	WiFi Dual-band 2.4/5GHz, Bluetooth 5.0.
Ports	HDMI 2.0, HDMI (EARC Supported), 2x USB 2.0, Type-A, LAN, 3.5mm aux, Optical, DC in.
Weight	6.39lbs
Dimensions	5.36 x 8.20 x 8.59 inches

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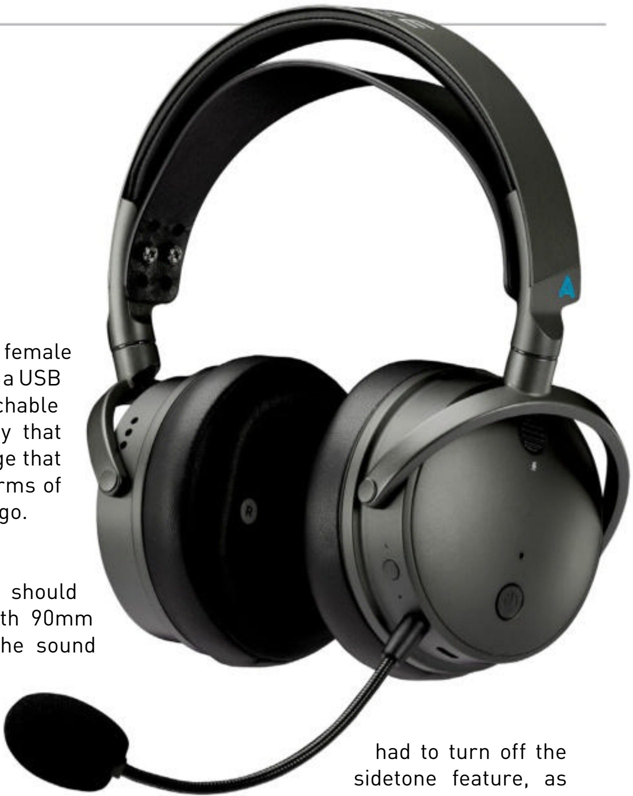
Audeze Maxwell

Bringing planar magnetic drivers to gaming



WHEN AN AUDIO POWERHOUSE like Audeze comes along with a gaming headset offering, it's hard for us to not want to get our hands on it as soon as possible. With peripherals such as the Penrose and Euclid impressing us massively, when the Maxwell was released we wanted to see what impact this could have in the gaming sphere. The Maxwell features a more minimalistic design than the previous Penrose gaming cans before it, without the typical gaming-related design queues you get with headsets. Is this more serious and high-end step forward equally impressive?

The Maxwell leans on a more circular design with huge, deep ear cups. The construction feels incredibly durable and premium, with minimal creaking from its steel and aluminum chassis. To the touch, it feels even more expensive than its price tag might imply, but that might come down to the weight, coming in at over 1lb, though that's not to say it's uncomfortable. This is one of the comfiest pairs of headphones we've tested. It features a similar ski-band style headband found on SteelSeries' headsets, which we're a huge fan of. This evens out the weight across your head to avoid areas of increased pressure over long durations. It also has three levels of adjustment, which we found to be plenty considering the band has some stretch in it anyway. Aside from the headband, the earcups are incredibly plush and large enough to completely swallow a range of ear sizes. After a long session of gaming, they barely caused any discomfort.

With a huge tick for design and comfort, what features does it offer? On the left earcup, you can find the power and mute button, volume wheel and microphone wheel, 3.5mm, USB Type-C port, and a noise-suppression button. With all that on one earcup, it leaves the right one feeling lonely. If anything, it would have been nice to see the volume wheel on the right to quickly distinguish it from the microphone volume. Other features include a whopping 80-hour battery life (after a few days of testing we didn't need to plug these in once), ultra-low-latency wireless through the USB Type-C dongle, Bluetooth 5.3, and a 3.5mm auxiliary connection. In the box, you get a USB Type-A to a female USB Type-C, a 3.5mm cable, a USB Type-C cable, and a detachable microphone. It's fair to say that this is a feature-rich package that covers a lot of ground in terms of what you have from the get-go.

INCREDIBLE AUDIO

On paper, these cans should rock, and boy do they! With 90mm planar magnetic drivers, the sound is powerful and punchy enough to provide your ears with nothing less than audio bliss. As this is predominately a gaming headset, we dived straight into some FPS titles to test out the spatial capabilities. It didn't take long to realize how accurate shots, footsteps, and the directional audio of this Audeze headset is and how important that is when it's this good. Swapping over to a cheaper pair of cans, we noticed the impact this had on our overall experience. Granted, we aren't exactly going to be appearing in the next eSports competition, but this added accuracy certainly gave us an advantage in competitive games. The highs were full of clarity, with a solid midrange and cracking bass to add to the immersion. The Maxwell nails everything you need in terms of audio for an incredible gaming experience.

This performance carries over when you listen to music. Again, with its punchy sound stage, you can feel every beat and hear every detail. We recommend downloading the Audeze HQ app on your PC when using the headset. This way, you can update the dongle and headset to keep them running at their best. Equally, you can alter the EQ presets—the default Audeze EQ offer's a great balance, but the bass boost option increases the atmospheric and cinematic immersion through bass you can feel from those huge drivers.

It's fair to say that it nails design, comfort, features, and audio quality. For use as a party chat headset, too, the included detachable microphone does a good job of picking up your voice clearly without much background noise. The only gripes were down to the software. We had to turn off the sidetone feature, as this was picking up far too much feedback. Equally, the application isn't the most polished piece of software we've seen, but again, this isn't the end of the world. The Maxwell proved itself as an outright gaming headset monster that can easily double as a premium pair of headphones too. Sure it's expensive but the price tag is fully justified by the experience you'll get. **–SAM LEWIS**

VERDICT
9
KICK ASS!

Audeze Maxwell Wireless Gaming Headset

⊞ **MAXIMUM** Punchy soundscape; immersive, precise details; pillow-like comfort; superb build quality; outstanding battery life.

⊟ **MINIMAL** No active noise cancellation; software gripes.

$299.99, www.audeze.com

SPECIFICATIONS

Driver Type	90mm Planar Magnetic driver
Frequency Response	10Hz - 50,000Hz
Connectivity	3.5mm auxiliary, Bluetooth 5.3, USB Type-C
Compatibility	PC, Mac, PlayStation 4 & 5, Nintendo Switch.
Battery Life	Over 80 hours (wirelessly).
Design Style	Closed back
Weight	1.08 lbs

© AUDEZE

Elgato Stream Deck +

Another classic iteration of Elgato's marvellous controller series

SINCE THE FIRST version of the Elgato Stream Deck launched a couple of years back, they've become a must-have accessory for streamers who want to make accessing their most used functions as easy as pie. There's now a family of these products, of which this Elgato Stream Deck + is just the latest.

The big new addition is a series of four knobs to the bottom of the Deck, which adds more analog and tactile functionality to a device that's literally a USB-powered button box. Elgato claims that those four dials will help integrate this particular Stream Deck into the wider brand of streaming gear that the Corsair-owned brand provides, such as its Wave line of microphones and sets of key lights. With the dials, you can adjust mic gain and key light color temperature, which is especially handy.

Each dial also has a press-down button for things such as muting. Speaking of more functionality, the Stream Deck software also has this Dial Stack feature, where you can assign multiple functions to a single dial. Outside of the addition of four metal and tactile dials, the Stream Deck + is another classic iteration of Elgato's marvellous product. There are a total of eight buttons that you can control, each with their own display so you can customize them using myriad selectable icons within Elgato's software. While the main use for these buttons is on Twitch or YouTube, or in programs such as OBS, there are a shedload of plugins available for other apps to make the Stream Deck + an excellent device for productivity.

For instance, you can control PowerPoint or Keynote presentations with it, as well as select specific functions in Photoshop. Or, if you're feeling particularly clever, there are even games you can play using the buttons. The long and short of it is that the Stream Deck + is an immensely enjoyable product to use, with seemingly endless amounts of functionality. Other versions of it may have more buttons, but the additional dials just add another form of control. All of these different doodads, plugins, and gizmos you can use with the Stream Deck + can be found within Elgato's Stream Deck software, which is remarkably easy to use.

WORTH THE PRICE?

Grabbing plugins for the Stream Deck is as easy as downloading them from the free store contained within the app, and once they're downloaded, they should show up on the right-hand side of the app's main interface. Getting them onto the Stream Deck + is a simple exercise in dragging and dropping. Mine's got media playback controls for Spotify, a widget for CPU power, as well as one for weather, an analog clock, and stocks.

The Stream Deck + is a good-looking contraption, with a solid construction that helps to justify the $200 price tag. The buttons themselves are pretty big, and the displays inside them are bright enough for both daytime and after-dark working, while the touch bar above the dials is also pretty responsive to use, as are the dials themselves. It's also convenient that all you need to use the device is the included USB Type-C cable. Hopefully one day Elgato will make a wireless version of the Stream Deck, but for now, a single USB Type-C cable is decent enough.

The Stream Deck + is a useful tool for not only streamers, but also those who want to make their workflows as simple and easy as possible. Slapping down 200 big ones for the sake of adding some dials may not appeal to some, though, not least if you already own a Stream Deck that comes with more buttons already and therefore as much if not more functionality as this one, just in a different form. For those of us who haven't had the pleasure of using one before, though, it's pretty easy to see the appeal. –**REECE BITHREY**

VERDICT
8

Elgato Stream Deck +

+ **DECKED OUT** Sleek build; easy-to-use software; lots of plugins; single Type-C USB connection.

− **HIT THE DECK** Not necessary; pricey versus standard Stream Deck.

$200, www.elgato.com

SPECIFICATIONS

No. of buttons/dials	8 buttons, 4 dials
Connectivity	USB Type-C
Cable	USB Type-C, detachable
Dimensions	140 x 138 x 110 mm
Weight	465g/ 1lbs

SteelSeries Stratus Duo

The budget controller of choice, or just a backup pad?

THERE ARE LOTS OF PEOPLE who remain strictly keyboard and mouse, people who use both keyboard, mouse, and also controllers merrily, and others who transitioned to the world of PC gaming from console beginnings and rely on gamepads for gaming. Whatever your preference, it's what you feel comfortable using and have been accustomed to that makes you enjoy gaming.

However, poor peripherals can degrade your gaming experience, so picking a top-quality product is important, but that doesn't always mean breaking the bank. For all of you controller lovers out there, SteelSeries's Stratus Duo is a wireless PC model that won't necessarily leave your wallet crying and offers some top-end tech. Yet, with other equally priced and impressive controllers on the market, will the Stratus Duo be the one you should add to your arsenal?

The controller is smooth, with no sharp cheap edges that sometimes blight third-party controllers. In fact, the build quality is impressive—it's light, but doesn't creak or flex. Weighing only 0.54 lbs, it's great to take on the go. Talking of traveling, this controller's name plays into its functionality. Duo refers to the two forms of wireless connectivity it offers, either Bluetooth or wirelessly through a USB dongle. With the latter option being the best choice if you're at home and want a faster connection with a smaller input delay, the Bluetooth option is preferable for when you're traveling and want to game on a tablet or phone. Pair this with the SteelSeries SmartGrip (sold separately for $9.99), and it'll form a nifty handheld console alternative.

It's only available in this all-black colorway, however. We're just grateful it's not been doused in the typical gamer aesthetic. It features the PlayStation-esque layout with the symmetrical joysticks, but with the ABXY buttons from Xbox/Windows controllers. In the middle, you have the home button with the select button to the left and the start/menu button to the right. Above that is a player indicator bar, so if you have your friends over you can easily tell who's who.

ERGONOMIC EXCELLENCE?

The back of the controller features the standard RB, LB, RT, and LT layout. We're big fans of these triggers, as they have a smooth linear actuation thanks to the Hall-Effect magnetic sensors inside, making them great for driving games. As for the buttons on the controller and the D-pad, unfortunately, these are slightly too mushy feeling. Also, it could do with being a bit wider overall. It's a shame, because ergonomically the handles feel comfortable. The same sizing issue was also prevalent on the joysticks. Again, they were a little too small, but still very accurate when testing on first-person shooters, such as our FPS benchmarking games, *Cyberpunk 2077* and *Metro Exodus*. Every controller takes some getting used to when switching, but this didn't take too much time at all. We became familiar with the Stratus Duo quickly, although our *Apex Legends* capabilities are beyond saving and aren't restricted by controllers, more just our lack of skills.

Self-loathing aside, the Stratus Duo would make a dependable controller, but probably a better secondary controller for when your pals visit or your siblings are nagging you to play with them. The build quality is strong and lightweight, and it's Steam enabled with a plug-and-play connection. Talking of which, there are plenty of connectivity choices, such as your PC, Android phone, and VR headsets—for example, the Oculus Go and Samsung Gear VR. This is switchable via the top of the controller, which is really handy on-the-go. Battery life is a healthy 20+ hours, making it great for traveling but unfortunately, it's charged via Micro-USB, which is also the wired option on this controller.

Although it's not excessively pricey, there are other options, such as the official Xbox controller (at the same price). Compared to that, we can't recommend the Stratus Duo—unless you're moving between PC and mobile, then this takes the edge. So despite it not being a poor product, it's just stuck in a tricky pricing bracket. –SAM LEWIS

VERDICT

6

SteelSeries Stratus Duo

+ **SKY-HIGH** Lightweight; great compatibility; smooth triggers; good connectivity.

− **BACK DOWN TO EARTH** Mushy buttons; small thumbsticks; Micro-USB.

$59.99, www.steelseries.com

SPECIFICATIONS

Compatibility	Windows, Android, VR
Ports	Micro-USB
Connectivity	Wireless Bluetooth, Micro-USB
Battery life	20+ hours
Weight	0.54lbs
Size	2.49 x 4.33 x 5.91 inches

After 18 years away, the revving chainsaws of *RE4* are back to haunt you.

SURVIVAL HORROR GAME

Resident Evil 4 Remake

This is not the greatest game ever. This is a tribute

MUCH LIKE LEON S. KENNEDY, Capcom wasn't in for an easy ride with this one. There are great games and then there are the classics, games so forward-thinking and complete that they shape entire corners of the games industry. In the case of *Resident Evil 4*, every third-person game since has worn its love for Capcom's masterpiece on its over-the-shoulder sleeves—everything from *Gears of War* to *Dead Space* to *The Last of Us* runs because Capcom showed them all how to walk. Remaking a game that remade its own genre is like trying to catch lightning in a bottle one more time.

Capcom almost managed it and, for the longest time, you'll think it did. The opening of the *Resident Evil 4 Remake* is outstanding, slightly streamlining the original route into the village to get you into the first big set-piece: A knock-down drag-out village brawl that, almost immediately, takes place with the constant sound of a chainsaw revving as its owner chases Leon everywhere.

For those who have completed the original game, hardcore difficulty level is recommended. The name is certainly fitting—I must have died in this encounter six times before beginning to figure out the endless tricks baked into Leon's moveset and the enemy's behavior. One difference you'll notice almost immediately on this difficulty level is that running away is not quite the god-tier strategy it once was. These ganados don't just run after you, but they will catch you and inflict grievous damage. One thing you'll soon realize in this game it's that, after the rather flavorless *Resident Evil 3: Nemesis*, Capcom has rediscovered the joy of killing players brutally.

The original came up with a new threat, the more human-seeming ganados and their swarming tactics, but the remake doubles down, making enemies tougher and more persistent while subtly altering Leon's toolkit to allow him to deal with it. This has always been a game about crowd control—keeping things off your back, whittling down a seemingly unbeatable mob to its last member, gritting your teeth, and blasting through a sea of bodies and tentacles. The remake throws everything at you and then, while you're gasping on the ground, the kitchen sink sails through the air right at your head.

This can be utterly exhilarating. *Resident Evil 4*'s greatest fights are all here, bigger than ever, and they also feel better than ever to wade through. The core of combat remains location damage, shooting enemies in the legs or head in order to stagger them then following up with melee attacks—a brilliant push-pull dynamic that sees you staying on the edge of mobs until you need to dash in and unleash a roundhouse or suplex. A brilliant new addition is the ability to parry with your knife (though of course not all attacks can be parried), leading to extended sequences of utter chaos where, through some combination of instinct and extreme firepower, Leon somehow walks away from an army with barely a scratch.

One great element of this is reticule wavering. The original game incorporated the idea that Leon's aim would always be slightly wobbly, and the remake takes this and runs with it. Hold out your pistol and, over a few seconds, the reticule will wobble vaguely around the point you're aiming at before settling and tightening up to a smaller area. Enemies won't wait around to give you time to line up your shot, so you'll need ice-cold nerves if you want to be an accurate gunslinger.

The *Resident Evil 4 Remake* makes some bold decisions about elements of the original and, in many cases, that decision is simply to remove them. Capcom has been upfront about the game removing the QTE elements (though these are still

© CAPCOM

The ganados still swarm you and generally make your life a living hell.

Like other *RE* remakes, this is a beautifully gruesome game.

Capcom has removed quick time events (QTE), much to the game's detriment.

Precision improves the longer you aim, but doing so isn't easy.

a part of combat in dodges and arguably even the parry) but it doesn't have any ideas about what to replace them with and so moments of great drama and peril just aren't here. If you have any familiarity with the game, you'll notice the absence of one, then another, then by the time you're near the end, sadly conclude this isn't going to deliver much of what it should.

GROTESQUE EXPERIMENTS

That might seem entitled. But *Resident Evil 4* was always a slightly crazy game, taking place in an unspecified European wonderland of bizarre contraptions, shooting galleries, medieval castles, and an endless menagerie of grotesque and toothy experiments. And a lot of it just hasn't made the cut. One iconic sequence, in particular, has been replaced with an utterly anodyne and short section that simply isn't fit to lace the original's boots.

This element of the remake begins to encroach more and more as the game hits its second-half stride, and can only be described as timidity. Where the original felt like it was constantly over-reaching, surprising the player with new demands, new environments, and wild one-off challenges, this seems content to settle into more of a standard corridor shooter rhythm. The combat is so good that even when the game's unambitious it is borne aloft on a cloud of shotgun shells, but the further you poke into its soft underbelly the more unambitious it begins to seem.

For those who haven't played *Resident Evil 4*, the experience of this remake will be discovering a very good third-person shooter and wondering why everyone made such a fuss about it in the first place. And the sad fact is that, where the original game was pioneering and ended up defining a genre, this remake is trammeled by that legacy and bound by what *Resident Evil 4*'s successors, almost all of which are inferior games, have done to the template.

Resident Evil 4 Remake undoubtedly improves on the original in some ways. Personally, I'll always miss the line "Your right hand comes off?" but the B-movie script is much-improved, and the way the storyline has been tweaked, in some cases significantly so, is well-handled and retains enough of the schlock factor that the personalities shine through. Ashley, doomed to forever be the damsel in distress, is now a much more forthright and capable companion, while Luis's reinvention retains the rogueish charm and sands off his more leery edges.

If *Resident Evil 4 Remake* was an original, standalone title, it would be a great game and anyone who plays this will have a good time (maybe not on Hardcore though, it really is brutal). But this is not a standalone game, it's a remake of one of the greatest games ever and it falls short. Where the original felt expansive, this feels cramped, and where the original went on breathless tangents, throwing one idea after another at the player, this feels (in the second half especially) like it settles into a groove and isn't especially interested in breaking free of it.

This is not the heir to *Resident Evil 4*, so much as a tribute. *Resident Evil 4 Remake* is a great third-person action game that takes too much inspiration from what followed, rather than what started it all in the first place. **–RICH STANTON**

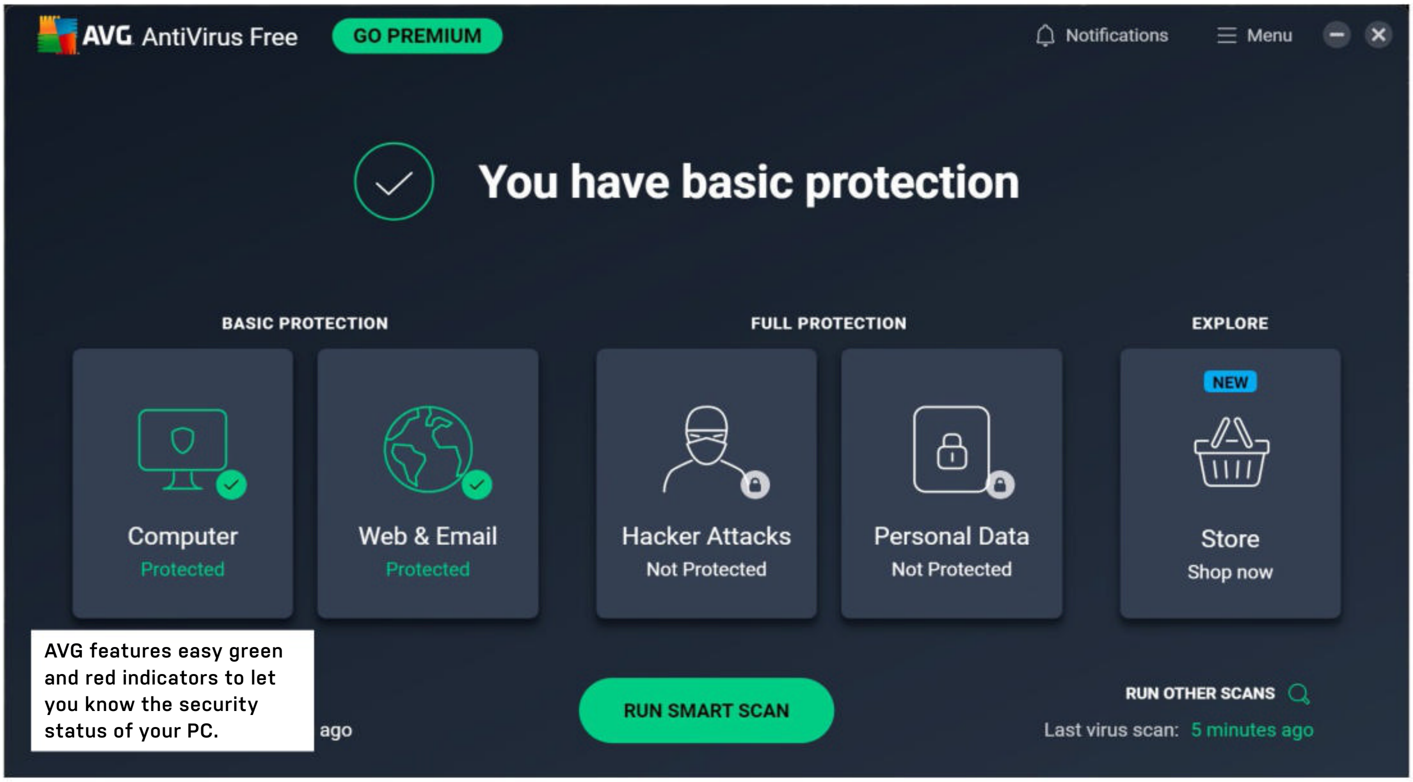
VERDICT
8

Resident Evil 4 Remake

⊞ **REMASTERED** Improved combat; better writing; beautiful visuals.

⊟ **NEEDS REPAIR** QTE elements are missed; timid second half; loses some of the original's charm.

$60, www.residentevil.com/re4, M-rated



You have basic protection

Last virus scan: 5 minutes ago

AVG features easy green and red indicators to let you know the security status of your PC.

AVG Free vs Avast One Essential

Which free shield should your PC wield?

EVEN IN THE PRIVACY of your home, you exist in a world where it's not safe browsing the internet unprotected. Someone somewhere wants to breach your personal information and use your data for monetary gains in some way or another, and it sucks, right? Whether that be through phishing, viruses, spyware, malware, etc, it's important to have trustworthy antivirus software, and you may not even need to pay for it. It's just worth having the peace of mind that you've got that extra level of security behind you.

We've chosen our two favorite web-protection applications to help you stay a little safer the next time you're browsing the web. With both offerings being big-time players in this field and providing a range of services to keep you protected, our two contenders for this head-to-head are AVG Free and Avast One Essential. Which one should you opt for?

As of Monday, October 3, 2016, Avast acquired a majority stake in AVG, meaning they operate as one single company, yet they decided to keep both applications separate. Adding more spanners to the mix, another antivirus giant, Norton, acquired Avast in 2020, so they now own both. Confused much? Norton aside, Avast and AVG have been competing for around 30 years, and have different qualities to differentiate them both. Starting things off, we'll be taking a look at AVG Free.

What AVG nails is a no-frills design. As soon as you open it, you're greeted by the main dashboard comprised of AVG's dark grey and green color scheme. Everything you need is right there, although it does a great job of reminding you that you have the basic free edition. Like most free versions of applications, there are plenty of incentives to upgrade to the premium package—for example, the 'go premium' button at the top, or showcasing some of the locked features on the home page.

The UI is clean and easy to navigate. All that you need is available from the start. You can run a Smart Scan by hitting the big green button at the bottom, which checks through your operating system and scans for malware and other advanced issues. If you want to do a more precise check through specific areas, hit the 'run other scans' icon to the right of the green button. Here, you can do a deep scan, performance scan, boot-up check, or scan through a file, folder, USB, or DVD.

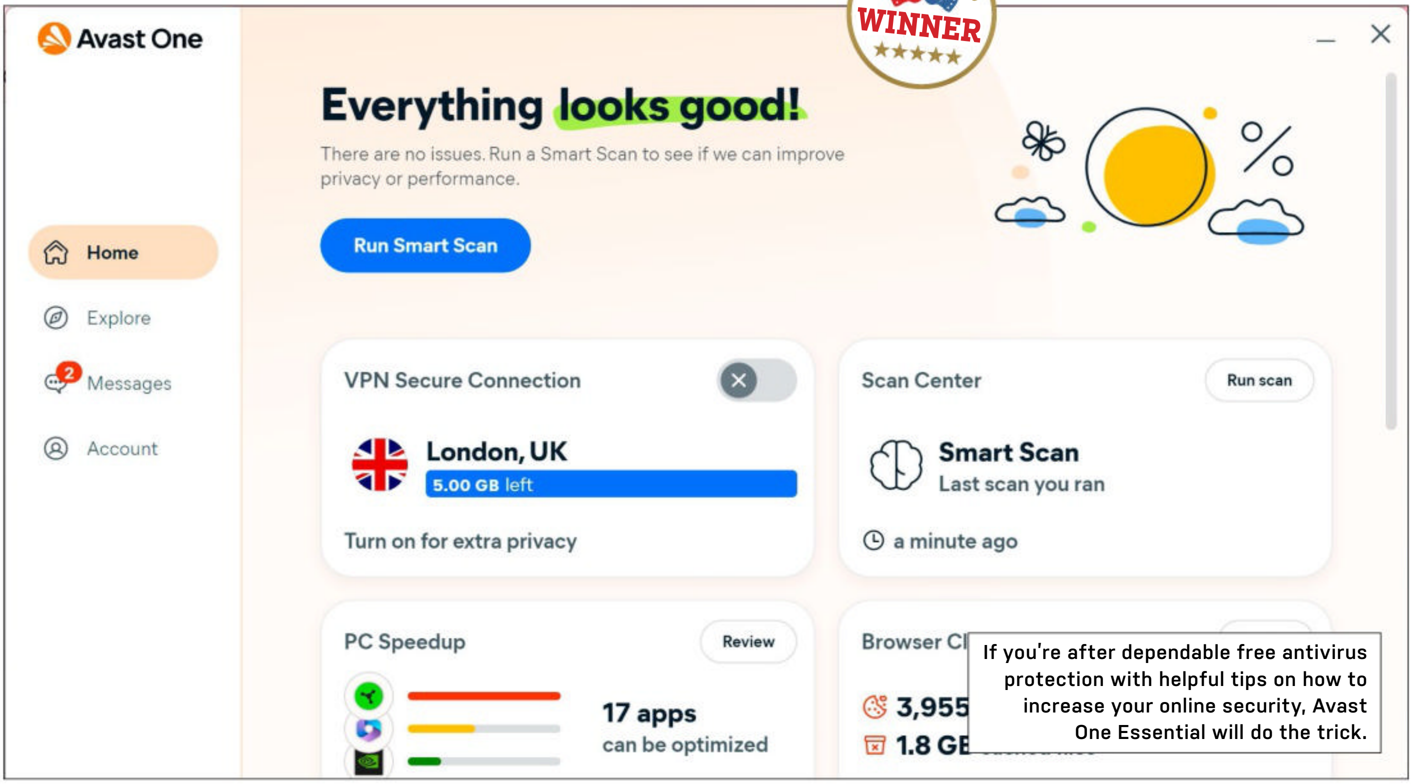
In the center you can see a Computer protection option, and next to that the Web & Email protection. If everything is okay, these will say 'protected' and have a green tick. If anything is out of the ordinary or under threat, it will turn red, making it easy to distinguish any issues with your security using AVG. The computer option provides real-time protection, and opening this provides you with four choices: File Shield automatically scans any new files added to your PC; Behaviour Shield warns you if any application is behaving maliciously; Ransomware Protection can wall off specific folders and apps, and Network Inspector checks to see if your internet is prone to any security issues. All of these options provide a sturdy level of protection, and can be toggled off if they're not needed.

In Web & Email protection, there are four toggled services: Web Shield to block suspicious downloads and web attacks; Email Shield to combat—you guessed it—unsafe emails and attachments; Firewall (which can be optionally installed), and Hack Alerts, which is activated when you sign up to an AVG account.

Furthermore, if you hit the settings icon, you can dive even deeper into each service, such as the sensitivity of the malware detection, toggling the automatic

© AVG

HEAD TO HEAD WINNER ★★★★★



There are no issues. Run a Smart Scan to see if we can improve privacy or performance.

If you're after dependable free antivirus protection with helpful tips on how to increase your online security, Avast One Essential will do the trick.

© AVAST ONE

fix function, enabling site blocking, etc. We loved how simple the application layout was, with all the nitty gritty options kept hidden within the settings so that the rest of the UI remains clean.

Turning over to Avast One Essential, there is a 'vast' design difference—bad pun, we know. Opposite to AVG's dark theme, Avast One Essential features a much brighter theme consisting of a light orange and peach color scheme and a more illustrative design. It works, although the AVG layout is easier to follow.

That's not to say the Avast interface isn't user-friendly. It follows a more vertical design, with the most important feature, the Smart Scan, up top. Much like the option on AVG, it checks browser threats, viruses, malware, and advanced issues. It will indicate where you can improve your security, idnetifying any potential threats. To resolve these issues, you'll have to upgrade to the premium package, again like AVG. What you get for free is essential privacy and protection.

Below the Smart Scan are other features, including a PC Speedup section where you can optimize background apps to help your PC run quicker. Most importantly, you can use to 5GB of VPN access per week to improve your privacy and browse more safely while on public networks. Upgrading to the premium package allows you to gain 24/7 VPN access and change the location. Another feature is the browser cleaner. Clicking on this allows you to choose what data you want to clear. Be aware that this will sign you out of everything, so have your passwords somewhere safe. Disk cleaning and driver updating utilities are available, but only as premium options.

Along the left side of the app below the home section is the explore tab, a more in-depth version of the home screen. Here, you'll find other device protection features where you can scan more precisely, such as File Shield, Web Shield, Ransomware Protection, Firewall, and Quarantine. These are also found within AVG Free—there's just a lot of overlap between the two. Underneath the device protection tab, you'll find the online privacy tools: VPN, clear browser data, privacy advisor, password protection, and email guardian. All of these are handy, but slightly restricted, with more settings being unlocked by the premium package. Below the online privacy tools area is the performance section, where you can optimize background apps, and a software updater to make sure you're running the latest versions of your applications.

SUMMARY

The main difference is that Avast One Essential offers a better aesthetically designed application in our opinion, with a fresher user interface, although if you want simplicity, AVG is easier to use. It's clear that they offer similar functionality, but Avast's software provides you with slightly more fine-tuning options and a free 5GB a week VPN feature. Granted, that's not a huge amount, but this was great to use in a coffee shop's public Wi-Fi for that added peace of mind.

The bottom line is that they both deliver in-depth antivirus protection for free, and if that's all you are after, then you'll be satisfied with either. As they're also fairly light applications, hardware strain isn't an issue, unlike many of the larger antivirus applications of yesteryear. For us, Avast One Essential just had an easier-on-the-eye approach and offered slightly more to the user than AVG Free, making Avast our winner. **–SAM LEWIS**

VERDICT **8**

AVG Free

➕ **CUT FROM THE SAME CLOTH** Handy design with a color identifier; a simplistic layout for ease of use; quick web & email protection.

➖ **A WHISKER AWAY** No VPN functionality; fewer features than Avast.

Free, www.avg.com

VERDICT **9**

Avast One Essential

➕ **ESSENTIAL** Great illustrative design; very intuitive UI; great protection.

➖ **INESSENTIAL** Many features are premium locked.

$0.00, www.avast.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Legibility concerns
> How to make games
> Creator PC needed
> Move fast, break things

Background Checks

I'm a longtime reader of your fine magazine, and hope to continue subscribing. However, your recent issue, April 2023, contains many pages I simply can't read. Beginning on page 74 until page 85, you've chosen to print the bulk of the text on dark green backgrounds and black text. This is impossible to read for me. I would implore you to use white or light yellow text when using a dark background—there needs to be substantial contrast between the text and the background. Similarly, if you are using a light background then black or dark blue would be most appropriate. Please have consideration for your readers that are over 40! **– F. Zlotnick**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: We've had a lot of feedback from people on the last couple of issues, and let me apologize to anyone who had trouble reading the copy. I've discussed this with our designer Fraser, and rest assured, we'll be using a more readable color scheme going forward. Apologies to everyone who contacted us about this issue.

Budget Windows

I know this has been covered before, but I can't find the answer in prior issues. All of your builds quote $32 for Windows 10. Where can one buy an OEM license for Windows 10 for $32? **– H. Sails**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: There are a number of places you can buy a Windows license at that price (or less), as I had to do this month when putting together a new desktop system. We don't recommend any particular retailers, but we base our figure on a few different key sellers, such as G2A.com, cjs-cdkeys.com, and kinguin.net. I've never had a problem when buying from such retailers, with the keys arriving within minutes after checkout. However, I make sure I always use a credit card so that there's someone I can talk to in case of any problems, and obviously check sites like Trustpilot to make sure retailers are legitimate before purchase. Oh, and I'd personally be buying a Windows 11 license if I was building a new system in 2023, but any Windows 10 purchases should be eligible for a free upgrade.

Game Making

If I wanted to start making triple-A games, do I need a professional grade graphics card or a consumer grade card or both (professional for development and consumer for testing)? And what about the processor (professional or consumer or both)? **–C. Williams**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: While I could do with a bit more detail on your questions, I've spent a good chunk of my career covering the games industry, so I can take an educated guess. However, I think it's a good idea to manage expectations—you shouldn't be hoping to make triple-A games on your own. By definition, triple-A games like *Grand Theft Auto*, *Assassin's Creed*, and *Call of Duty* take hundreds of people many years to produce, burning through hundreds of millions of dollars along the way, so assuming you don't have access to those kind of resources, you might want to aim a little modestly at first.

The good news is that it has never been easier to make a game on your own, with a vast array of free or cheap resources available to help you get started. To answer your main questions, you won't need anything fancy when it comes to hardware to run Unity or Unreal Engine, both of which are very popular tools for making

↘ submit your questions to: editor@maximumpc.com games. I'd recommend Unity out of the two, which tends to be used for less graphically intensive games like mobile or traditionally "indie" titles. *Cuphead*, *Genshin Impact*, *Hearthstone*, and *Cities: Skylines* were all made using Unity, and are all fantastic. The good news is that you can download it for free to try out. I'd start by following video tutorials, such as those at youtube.com/Imphenzia, whose Unity intro course will have you making a basic platform game or endless runner within hours.

If you're able to think up enjoyable game mechanics and implement them well, then you can release your game independently, or use it as a calling card when applying for a job at a professional games studio. Obviously, if you want to specialize in a discipline such as art, music, or AI, then you will need to go in a slightly different direction, but using Unity or Unreal Engine is a great starting point. Good luck!

Getting Creative

I plan to build a computer that will be used primarily for content creation. I edit with Avid Media Composer and build visual effects with After Effects, Mocha, and Photoshop or Affinity Photo. I'll keep some components from my last build (like an LG 1440p ultrawide and a Benq UHD monitor, and an Nvidia Quadro P4000 video card).

I'm thinking of using an M.2 boot and application drive, plus a large HDD for all my larger files, and a decent amount of RAM. The case goes under my desk, so lighting and case windows would be wasted on me.

What do you recommend I use for a motherboard and CPU? I'd like to keep the whole build to around $3,000 to $4,000 CAD (I'm writing from Canada). I tried PCPartPicker and found it to be overwhelming with options that I couldn't figure out how to narrow down, so I am turning to your wisdom and experience. **– J. Lawson**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: Sounds like an exciting project! Sam and I have been discussing a creativity-focused cover build for an upcoming issue, so we share your excitement. For now, though, let's try to answer your question.

First of all, yes on the SSD, as it will definitely improve your productivity overall. I'd even be tempted to get a nice big 2TB or 4TB drive if you're using large files—I've seen Western Digital's SN850X 4TB drive for under $350 this month, which is just about the best drive you can buy right now till the arrival of PCIe 5.0 models later this year. I also just upgraded my gaming desktop and have a large Steam library, so I went for an 18TB Toshiba Enterprise Internal Hard Drive, which was just under $300.

When it comes to a processor, you do sound like a high-end user, so I'd be tempted to go with the Intel Core i7-13600K for about $300 or i9-13900K for about $550. The former chip is very fast and offers roughly the same performance as the previous generation top-end 12900K chip, and will tear through any of the apps you mentioned. I'd also be tempted to go for a Z790 motherboard like the ASRock Z790 Pro RS, which supports DDR5 memory, but is less than $200—a great buy. You can also get a DDR4 version for about the same price if you want to reuse any existing RAM.

Even with the large-capacity SSD and HDD, that should all come well under budget. I'll admit that GPUs for creatives are not my personal area of expertise, I'd also look at upgrading this, as it's nearly six years old now. If your primary use is creative applications, particularly Adobe's, then the company has incorporated GPU acceleration into quite a few of its apps for the latest Nvidia GPUs, so you might notice a reasonable performance leap here. Have fun!

Learning From Mistakes

I love reading about the builds every month, but in every build, something always seems to go wrong (I appreciate the honesty). For this reason, I'm afraid to try building my own system (I don't have parts laying around). Maybe you will consider showing us the cost to buy a pre-built, comparable system from a reputable builder? Perhaps the cost differential isn't high enough to warrant trying to do it myself (or maybe it is)? **– S. Jaber**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: I've had feedback from readers saying they love that we include the errors and mistakes we encounter when putting together builds, because truth be told, even experienced builders like our staff writer Sam have issues. It's why I wanted to include a new feature in our digital magazine where Sam and I discuss the challenges of that month's build, and how we'd do things differently if we were going to do it all over again. I hope you like the new feature, which you can check out on page 16.

Overcoming problems and fixing errors is very much the *Maximum PC* way, and that undoubtedly appeals to a smaller, more patient, methodical, and problem-solving audience than the mass market who just wants to buy a pre-assembled and tested desktop or laptop. Believe me, when I'm tearing my hair out because a build just won't work, or I need to send a GPU back for repair and have to wait a month for it to come back, I run headfirst into the open arms of my laptop, which I know will just work. But because you're able to specify your own components, save money, and easily upgrade, there's just no beating a self-built desktop PC.

Blueprint Capabilities

I would like to see what each PC in each section of the Blueprints can run. For budget builds, can it run 1080p, what games can you run and more? Could you just add a paragraph saying what it can run, because the prices have been dropping in the budget build section a ton, and I would like to know what it can run to see if it's a good fit for what I want to do. **– C. Damron**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: Perhaps we need to do a better job of explaining this in the Blueprints section, so thanks for asking the question. Yes, broadly speaking, the three builds represent 1080p/1440p/4K gaming at high settings, with a couple of caveats. The main one is the Budget build, which we've locked in at sub-$1,000 for now—quite a challenge given current inflation levels of 10 percent+! At the high-end, our Turbo build is actually capable of going up to 8K if you have a compatible TV. Hope that clears things up!

THE BUILDS

THIS MONTH'S STREET PRICES...

AFTER COMPLETING A budget Intel build under the $1000 mark for this month's cover build, we thought we'd take a few things from there to bring costs down further across both our Blueprint budget machines. First things first, we decided to upgrade our Intel i3-12100 to a newer Intel Core i3-13100F. Yes, it being an F model means it requires a GPU. However, because we are adding one, we can save a few bucks on the CPU. Also, this 13th gen i3-13100F is cheaper than the previous i3-12100 by $13, so for this system, it's a no-brainer. It will more than likely require a BIOS update on our motherboard, though. This may require you to have an older CPU to boot it up into the BIOS, so always bear that in mind when upgrading to the next-gen CPU, even if it states it's compatible.

The other change to the Intel budget machine was to bring in the Intel ARC A750 we used from our cover build to replace the Asus TUF Gaming EVO OC GeForce GTX 1660 Ti 6GB GPU. The latter card went from $260 last issue up to $300 now. The Intel card is newer, cheaper, and has faster GPU and clock speeds, and we experienced comfortable 1080p gaming. Other than the CPU/GPU changes, the build remained the same. We saw price decreases on our motherboard and SSD, and our total price went down by $100. It's now close to our AMD machine in overall cost.

We also made a CPU change on the AMD rig due to the ending of a sale on our AMD Ryzen 5600X, which was $155. We decided to opt for the non 'X' variant, the standard 5600, as this is near enough identical in specs and can be picked up from Amazon on sale currently at $160. The difference is it just has a slightly slower base frequency (3.5GHz compared to 3.7GHz) and a slightly slower max boost clock (4.4Ghz compared to 4.6Ghz). That was the only change we made, and with a slight SSD price decline, our AMD budget build went from $775 to $765.

AMD INGREDIENTS

PART		PRICE
Case	Corsair 4000D Airflow	$95
PSU	450W Corsair CV450 80+ Bronze	$59
Mobo	MSI B550M PRO-VDH WIFI Micro ATX AM4 Motherboard	$119
CPU	AMD Ryzen 5 5600 **NEW**	$160
GPU	MSI MECH 2X OC Radeon RX 6500 XT 4GB	$165
RAM	16GB (2x 8GB) PNY XLR8 Gaming EPIC-X RGB DDR4 @ 3200MHz	$55
SSD	500GB PNY CS2140 PCIe 4.0 M.2 SSD	$30
HDD	2TB Seagate Barracuda Compute 7200	$50
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32

Approximate Price: $765

INTEL INGREDIENTS

PART		PRICE
Case	Corsair 4000D Airflow	$95
PSU	450W Corsair CV450 80+ Bronze	$59
Mobo	ASRock B660M-HDV Micro ATX LGA1700	$85
CPU	Intel Core i3-13100F **NEW**	$120
GPU	Intel Limited Edition Arc A750 8GB **NEW**	$250
RAM	16GB (2x 8GB) PNY XLR8 Gaming EPIC-X RGB DDR4 @ 3200MHz	$50
SSD	500GB PNY CS2140 PCIe 4.0 M.2 SSD	$30
HDD	2TB Seagate Barracuda Compute 7200	$50
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32

Approximate Price: $771

MID-RANGE

WITH MORE VIRTUAL MONEY, our mid-range builds have larger scope for faster components, but that's not to say we don't want to keep costs down. When we revisited our AMD mid-range build, for instance, our CPU and GPU prices increased by $50. So to save money, we did exactly what we did on the AMD budget machine and applied it here. We substituted the AMD Ryzen 7 7600X for the Ryzen 7 7600. They both share the same six Zen 4 cores and 38MB of cache—it's just that the non 'X' variant has a lower 3.8GHz base clock compared to the 7 7600X, at 4.7GHz. Also, the 7 7600's max boost clock is 0.2GHz slower at 5.1GHz.

The price difference is currently around $70. Plus, with some slight automatic overclocking using AMD's Precision Boost Overdrive (PBO) through the AMD Ryzen Master Utility app, you can get the Ryzen 7 7600 up to similar performance figures as the Ryzen 7600X. The Ryzen 7 7600 also comes with an AMD Wraith Stealth cooler, unlike its more expensive sibling. This was the only change we made this time for the AMD mid-range build, resulting in a total price of $1,412. That's only $2 more than the last, but it would have been more if we hadn't changed the CPU.

On the mid-range Intel build, price differences forced us to change components here, too. Last issue, our GPU, the ASUS GeForce RTX 3060 Ti TUF GAMING OC 8GB, cost $480, but thanks to the Gigabyte GeForce RTX 3060 Ti EAGLE OC 8GB coming back in stock, we've opted for this, as it's $440 and offers similar performance. We also chose the Intel Core i5-12600KF over the previous i5-12600K to save money, as we don't need the Intel integrated UHD Graphics 770 thanks to our 3060 Ti. The 12600K was $225, but is now back at $250. You can pick up the 12600KF for $225, so if you have a dedicated GPU, it makes sense to save some money and go for the 'F' variant. Overall, the price is now $53 lower while delivering the same performance.

AMD INGREDIENTS

PART		PRICE
Case	NZXT H7 Flow	$130
PSU	750W EVGA 750 BP 80+ Bronze	$90
Mobo	ASRock B650M PG RIPTIDE WIFI Micro ATX AM5	$190
CPU	AMD Ryzen 5 7600 **NEW**	$230
Cooler	Cooler Master MASTERLIQUID ML240L RGB V2	$92
GPU	Gigabyte Radeon RX 6750 XT Gaming OC 12GB	$400
RAM	32GB (2x 16GB) Corsair Vengeance DDR5 CL40 @ 4800MHz	$108
SSD	1TB Crucial P5 Plus NVME M.2 PCIe 4.0	$90
HDD	2TB Seagate Barracuda Compute 7200	$50
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32

Approximate Price: $1,412

INTEL INGREDIENTS

PART		PRICE
Case	NZXT H7 Flow	$130
PSU	750W EVGA 750 BP 80+ Bronze	$90
Mobo	Gigabyte Z790 UD AC ATX LGA 1700	$195
CPU	Intel Core i5-12600KF **NEW**	$225
Cooler	Cooler Master MASTERLIQUID ML240L RGB V2	$92
GPU	Gigabyte GeForce RTX 3060 Ti EAGLE OC 8GB **NEW**	$440
RAM	32GB (2x 16GB) Corsair Vengeance DDR5 CL40 @ 4800MHz	$108
SSD	1TB Corsair MP600 PRO NH M.2 PCIe 4.0	$83
HDD	2TB Seagate Barracuda Compute 7200	$50
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32

Approximate Price: $1,445

TURBO

AT THE TOP OF OUR LIST are the Turbo builds. With the most amount of virtual money to play with, we only wish we could have these systems for ourselves, but then again, don't we all? These are made for showing off the latest and greatest components, but on the flip side, if we can save a bit of money here and there, we will try to.

The most important component for performance is the GPU. In the Intel machine, we are using an RTX 4090. Last issue, we used the ASUS GeForce RTX 4090 TUF GAMING OC 24GB, as this was one of the 'cheapest' at $1,619. That has shot up to around $1,800, which is just too much considering we found the replacement, the Zotac GeForce RTX 4090 GAMING Trinity OC 24GB for $1,635.

You could get the non-OC variant for $1,600, but if you're paying that much, the extra out-the-box performance is worth that $35. Other than the GPU, the PSU changed over from Corsair to NZXT as the former PSU went up in price to $190, while the NZXT C1000 comes in at $180. With a few price fluctuations, such as our CPU increasing and RAM and SSD decreasing, the overall price didn't change much, rising from $3,389 to $3,397.

Last but not least, we turn our attention to the AMD Turbo. The GPU is the Radeon RX 7900 XTX again—we have found a cheaper model which we will be swapping to. Previously we had the XFX Radeon RX 7900 XTX Speedster MERC 310 Black Edition 24GB, which costs $1049, replaced with ASRock's Radeon RX 7900 XTX Phantom Gaming OC 24 GB GPU. Not only is this an overclocked card, but it's currently $980, so saves us $70.

We've also replaced the Cooler Master MasterLiquid ML360R RGB 66.7 CFM 360mm with an Asus ROG STRIX LC II ARGB 360mm. There was a stock shortage for the Cooler Master AIO that increased the price—at $190, this alternative ASUS 360mm AIO cooler is more than enough. As we have recently overhauled these systems, the rest of the PC is in a good place. We brought over the same NZXT C1000 PSU too, due to the same increase in the price of the previous Corsair RM1000. In total, then, this brings the price to $2,666 from $2,744.

AMD INGREDIENTS

PART			PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass		$190
PSU	1000W NZXT C1000 80+ Gold	NEW	$180
Mobo	ASRock X670E PG Lightning ATX AM5		$260
CPU	AMD Ryzen 9 7900X		$424
Cooler	Asus ROG STRIX LC II ARGB 360mm	NEW	$190
GPU	ASRock Phantom Gaming OC Radeon RX 7900 XTX 24GB	NEW	$980
RAM	64GB (2x 32GB) Corsair Vengeance DDR5 CL40 @ 5200MHz		$215
SSD	1TB WD Black SN850X M.2 PCIe 4.0		$95
HDD	6TB WD Blue 5400 HDD		$100
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)		$32
Approximate Price:			**$2,666**

INTEL INGREDIENTS

PART			PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass		$190
PSU	1000W NZXT C1000 80+ Gold	NEW	$180
Mobo	Gigabyte Z790 UD AC ATX LGA 1700		$195
CPU	Intel Core i9-13900K		$570
Cooler	NZXT Kraken X73 73.11 CFM 360mm		$185
GPU	Zotac GeForce RTX 4090 GAMING Trinity OC 24GB	NEW	$1,635
RAM	64GB (2x 32GB) Corsair Vengeance DDR5 CL40 @ 5200MHz		$215
SSD	1TB WD Black SN850X M.2 PCIe 4.0		$95
HDD	6TB WD Blue 5400 HDD		$100
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)		$32
Approximate Price:			**$3,397**

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